XV. *Reduction of Anemograms taken at the Armagh Observatory in the Years 1857–63.* *By* T. R. Robinson, *D.D., F.R.S., F.A.S., &c.*

Received June 11, 1875,—Read June 17, 1875.

In the beginning of the year 1845 I erected a self-recording anemometer at the Armagh Observatory, and have a series of its records up to the present time, unbroken except by accidents to the apparatus or occasional illness of the observers. I, however, soon found it was impossible for me and my single assistant to reduce continuously the mass of materials which was accumulating, without neglecting the primary objects of the establishment; and I was obliged to content myself with preserving them, in hope that they might be available to future inquirers. It was thought, however, by some distinguished members of the Royal Society that it was desirable to ascertain how far such observations are able to develop any definite laws amid the seeming lawlessness of the wind; and a grant was made to me from the Government Grant sufficient to discuss the anemograms for the seven years from 1857 to 1863. The work has been long delayed by the death of one of the computers, the migration of another to India, and my own temporary blindness.

The anemograph is that described by me in the 'Transactions of the Royal Irish Academy,' vol. xxii. It differs in nothing essential from that employed by the Meteorological Committee of the Royal Society: the recording-apparatus is different, and the direction is observed by a vane whose excursions are controlled by a peculiar contrivance instead of by a windmill. The space-records were read to 0·25 of a mile (statute), and the directions to 0°·5. The S. and W. components of the hourly velocity were computed for each to two places of decimals.

Wind is caused by a difference of pressure in the air over adjacent portions of the earth's surface; but of the agencies which produce this difference we as yet are imperfectly informed. Heat is obviously a most important one. We see that the action of the sun must produce a current from polar towards equatorial regions, and that when the geographical conditions of districts not too far asunder are such as to make their temperatures unequal, air-currents between them will result. The changes of solar action at a given place depending on the hour of the day and the day of the year, ought to produce definite periodical modifications of the wind; and the currents due to the varying tension of aqueous vapour ought to be similarly periodical. Were these the only causes of the wind, there seems no reason why its force and direction at a given time and place might not be predicted as certainly as the sun's altitude. But there are evidently disturbing agencies of great power which entirely mask the regular course of the phenomena, and of whose nature we can only form vague conjectures. The accumulation of ice in the polar regions forming icebergs may be such an influence; and what we have learned recently of the action of the larger planets on the solar spots, and of the connexion of the development of those spots with the magnetic storms and auroral discharges of our own planet, may suggest the possibility of extra-terrestrial forces playing some part in the question before us. But without following in the track of imagination, this is certain, that however complicated and irregular a phenomenon may be, if we have a sufficient number of observations, it is possible to determine the values and periods of those parts of it which are subject to definite laws. Where any of these periods agree with those of agents whose influence is certain, they may be referred to them with certainty, and their effect eliminated, making it much easier to deal with the residual phenomena.

In the present instance the want of self-recording instruments for pressure, temperature, and vapour-tension compelled me to consider the wind solely in reference to time, as depending on the hour of the day and on the month; and even with this simplification it is not easy to come to precise results. Were we to seek a velocity and direction which might be considered *normal* for each hour of the year, such is the irregularity of the air-currents, that I think it could scarcely be obtained in less than 100 years. Even if we confine ourselves to the west and south components, and take for successive hours the mean of the seven years concerned, it differs so widely from the means of the preceding and following hours, that any existence of law might seem impossible. But if the hour-means be taken for 20 or 30 successive days, their means present a very different aspect. I have taken them for months.

Before dealing with these components, I think it may be instructive to present a Table giving a synoptic view of the winds, which may show their general character at Armagh during the seven years concerned. It gives for each month and for each octant of the horizon (S. to S.W., S.W. to W., &c.) the mean hourly velocity, the mean direction, and the approximate number of hours during which this wind has blown.

At the end of each month is given the maximum hourly velocity for each year, the number of hours when the velocity exceeded 25 miles, and the number of hours during which the anemograph has recorded 0. This does not imply that during this time there was no wind, but that there was not enough to move the instrument. This requires a velocity$=1^{m}\cdot 74$.

The direction-vane is much more sensitive (very much more so than the windmill-apparatus now used to record the direction), and therefore the records of direction are more numerous than those of velocity.

TABLE I.—January.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S.	Vel.......	16′·46	16′·94	18′·17	13′·89	16′·46	12′·97	17′·67	Mean 16′·07
to	Dir.......	28°·7	24°	28°	21°	22°	24°	27°	Mean 25°
S.W.	Hours...	181	211	199	188	249	216	275	Sum 1519
S.W.	Vel.......	12′·7	17′·09	14′·66	9′·97	11′·43	14′·35	16′·20	Mean 13′·78
to	Dir.......	66°·67	58°	60°	63°	60°	63°	60°	Mean 61°
W.	Hours...	193	168	412	193	88	192	211	Sum 1457
W.	Vel.......	12′·24	10′·57	10′·28	10′·75	5′·30	8′·89	17′·49	Mean 10′·79
to	Dir.......	103°	112°	103°	107°	120°	114°	107°	Mean 109°
N.W.	Hours...	130	53	65	40	27	88	80	Sum 483
N.W.	Vel.......	10′·65	5·76	5′·32	5′·85	6′·00	4′·70	5′·73	Mean 6′·29
to	Dir.......	152°	150°	156°	146°	146°	156°	163°	Mean 153°
N.	Hours...	92	46	26	40	3	57	38	Sum 302
N.	Vel.......	5′·15	0	5′·43	7′·60	6′·63	6′·50	8′·56	Mean 5′·70
to	Dir.......	183°	223°	202°	208°	212°	206°	188°	Mean 203°
N.E.	Hours...	106	1	8	62	76	2	45	Sum 300
N.E.	Vel.......	6′·39	0	1′·70	6′·90	14′·89	23′·22	11′·23	Mean 9′·19
to	Dir.......	259°	0	242°	242°	247°	265°	247°	Mean 250°
E.	Hours...	31	0	18	40	54	9	30	Sum 200
E.	Vel.......	2′·10	13′·11	5′·67	11′·02	4′·70	17′·21	7′·95	Mean 8′·82
to	Dir.......	294°	307°	291°	293°	300°	287°	290°	Mean 295°
S.E.	Hours...	5	37	4	88	77	43	21	Sum 275
S.E.	Vel.......	15′·04	18′·59	13′·67	15′·97	13′·62	20′·60	10′·15	Mean 15′·38
to	Dir.......	346°	335°	344°	338°	337°	339°	322°	Mean 337°
S.	Hours...	12	228	12	93	170	135	45	Sum 695
Maximum		44′·2	46′	68′	60′	37′	48′	47′	......
Hours > 25′		23	92·3	98	68	40	95	146	Sum 562
Hours of 0		0	3	7	21	12	6	15	Sum 64

TABLE I.—February.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S.	Vel.......	17′·48	16′·36	16′·19	16′·01	4′·63	12′·30	15′·19	Mean 13′·55
to	Dir.......	19°·0	15°	21°	21°	23°	26°	28°	Mean 22°
S.W.	Hours...	177	56	184	110	118	155	183	Sum 1003
S.W.	Vel.......	11′·18	11′·52	14′·53	13′·32	12′·17	11′·85	14′·24	Mean 13′·22
to	Dir.......	57°	60°	66°	60°	65°	66°	61°	Mean 62°
W.	Hours...	149	40	159	167	110	112	192	Sum 935
W.	Vel.......	7′·59	5′·81	8′·60	9′·62	9′·69	7′·00	12′·01	Mean 9′·24
to	Dir.......	100°	118°	95°	108°	112°	93°	99°	Mean 103°
N.W.	Hours...	61	26	140	156	48	1	72	Sum 504
N.W.	Vel.......	2′·31	4′·78	0	6′·99	7′·30	3′·13	2′·50	Mean 6′·26
to	Dir.......	149°	162°	0	157°	175°	76°	172°	Mean 165°
N.	Hours...	8	18	0	129	20	8	11	Sum 194
N.	Vel.......	5′·50	6′·49	2′·50	5′·75	13′·28	7′·48	17′·05	Mean 8′·38
to	Dir.......	215°	201°	215°	188°	200°	201°	205°	Mean 203°
N.E.	Hours...	11	48	6	77	50	61	19	Sum 272
N.E.	Vel.......	5′·83	7′·41	2′·27	4′·65	8′·73	8′·63	2′·35	Mean 6′·96
to	Dir.......	247°	248°	233°	237°	233°	265°	247°	Mean 244°
E.	Hours...	63	122	15	51	33	97	4	Sum 385
E.	Vel.......	5′·20	15′·57	6′·32	1′·00	14′·49	10′·51	16′·78	Mean 13′·61
to	Dir.......	302°	292°	301°	295°	294°	292°	29[illegible]°	Mean 295°
S.E.	Hours...	5	45	25	4	68	102	14	Sum 263
S.E.	Vel.......	14′·60	17′·66	19′·23	1′·00	7′·17	18′·23	12′·96	Mean 14′·87
to	Dir.......	348°	338°	342°	337°	313°	358°	340°	Mean 339°
S.	Hours...	98	111	43	2	104	36	71	Sum 465
Maximum		44′·5	42′	40′	37′	45′	46′	56′	......
Hours > 25′		43	91	63	25	36	54	85	Sum 397
Hours of 0		3	1	6	3	5	4	4	Sum 26

Table I.—March.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S.	Vel.......	16'·50	11'·15	20'·35	13'·57	17'·70	11'·85	15'·40	Mean 15'·19
to	Dir.......	20°	27°	32°	27°	27°	30°	21°	Mean 26°
S.W.	Hours...	107	115	98	131	276	92	209	Sum 1028
S.W.	Vel.......	14'·90	9'·31	15'·70	16'·27	14'·25	13'·18	13'·00	Mean 13'·80
to	Dir.......	73°	68°	62°	67°	67°	69°	65°	Mean 67°
W.	Hours...	173	199	368	193	292	61	209	Sum 1495
W.	Vel.......	9'·77	9'·59	10'·90	10'·67	13'·13	10'·16	14'·97	Mean 11'·31
to	Dir.......	117°	110°	117°	113°	107°	114°	107°	Mean 112°
N.W.	Hours...	62	222	184	279	89	19	103	Sum 958
N.W.	Vel.......	6'·45	7'·48	9'·30	9'·29	8'·38	5'·86	6'·34	Mean 7'·59
to	Dir.......	172°	161°	147°	151°	149°	153°	156°	Mean 156°
N.	Hours...	69	65	67	70	8	42	38	Sum 359
N.	Vel.......	8'·58	13'·86	12'·50	7'·78	1'·50	8'·96	6'·19	Mean 8'·48
to	Dir.......	241°	209°	197°	202°	195°	206°	200°	Mean 207°
N.E.	Hours...	80	90	14	18	2	96	37	Sum 337
N.E.	Vel.......	6'·55	19'·75	11'·00	5'·00	8'·68	11'·30	6'·61	Mean 9'·84
to	Dir.......	264°	233°	255°	245°	249°	236°	243°	Mean 246°
E.	Hours...	98	28	7	23	19	248	18	Sum 441
E.	Vel.......	11'·58	4'·80	24'·50	7'·50	20'·50	11'·31	12'·39	Mean 13'·23
to	Dir.......	274°	279°	282°	272°	285°	304°	289°	Mean 284°
S.E.	Hours...	64	5	6	4	6	74	36	Sum 195
S.E.	Vel.......	13'·71	12'·00	0'·00	18'·38	13'·88	11'·53	15'·94	Mean 12'·21
to	Dir.......	350°	352°	...	341°	346°	334°	351°	Mean 346°
S.	Hours...	91	20	...	26	50	112	97	Sum 396
Maximum		49'·5	50'	58'	54'	43'·2	57'	40'	......
Hours > 25'		45	39	49	35	18	9	55	Sum 250
Hours of 0		3	5	1	4	12	4	1	Sum 30

Table I.—April.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S.	Vel.......	12'·38	9'·88	14'·11	11'·23	8'·67	13'·37	14'·90	Mean 12'·08
to	Dir.......	36°	42°	24°	19°	23°	25°	28°	Mean 28°
S.W.	Hours...	67	125	116	92	61	181	203	Sum 845
S.W.	Vel.......	9'·86	7'·50	11'·72	14'·06	5'·49	12'·45	12'·13	Mean 10'·39
to	Dir.......	74°	61°	62°	64°	61°	63°	66°	Mean 64°
W.	Hours...	65	76	150	50	33	131	183	Sum 688
W.	Vel.......	8'·73	7'·38	7'·29	8'·86	5'·33	9'·38	10'·70	Mean 8'·15
to	Dir.......	114°	117°	116°	103°	115°	110°	112°	Mean 112°
N.W.	Hours...	115	65	54	111	126	42	98	Sum 611
N.W.	Vel.......	6'·79	6'·00	6'·20	8'·64	5'·27	6'·53	9'·25	Mean 6'·93
to	Dir.......	154°	164°	157°	163°	155°	136°	157°	Mean 155°
N.	Hours...	60	73	93	119	78	69	55	Sum 547
N.	Vel.......	5'·29	5'·92	6'·68	13'·28	6'·30	6'·30	7'·50	Mean 7'·18
to	Dir.......	201°	197°	206°	200°	202°	199°	184°	Mean 198°
N.E.	Hours...	49	59	89	46	175	83	2	Sum 503
N.E.	Vel.......	8'·20	13'·98	15'·28	6'·47	6'·79	6'·36	0'·00	Mean 8'·13
to	Dir.......	251°	255°	250°	247°	248°	241°	......	Mean 213°
E.	Hours...	126	84	153	57	107	22	......	Sum 549
E.	Vel.......	12'·47	16'·78	16'·04	8'·73	9'·52	3'·55	8'·64	Mean 10'·82
to	Dir.......	286°	288°	284°	290°	284°	292°	302°	Mean 289°·5
S.E.	Hours...	113	153	49	100	98	45	28	Sum 586
S.E.	Vel.......	14'·73	16'·43	14'·60	10'·40	13'·58	13'·01	13'·05	Mean 13'·55
to	Dir.......	335°	335°	346°	338°	333°	339°	343°	Mean 338°
S.	Hours...	102	81	15	75	40	88	78	Sum 479
Maximum		45'·5	57'	46'	34'	23'·5	36'	58'	......
Hours > 25'		17	27	43	5	0	24	40	Sum 156
Hours of 0.........		26	108	10	24	5	21	6	Sum 200

TABLE I.—May.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S. to S.W.	Vel......	15′·31	11′·09	6′·55	8′·21	7′·07	9′·60	12′·39	Mean 9′·95
	Dir......	27°	27°	21°	17°	27°	24°	27°	Mean 24°
	Hours...	134	165	86	204	120	158	149	Sum 1016
S.W. to W.	Vel......	6′·87	10′·18	4′·32	5′·98	5′·55	9′·84	8′·67	Mean 7′·34
	Dir......	70°	71°	62°	69°	65°	64°	65°	Mean 67°
	Hours...	54	138	50	96	226	174	218	Sum 956
W. to N.W.	Vel......	8′·19	4′·72	2′·89	7′·24	4′·03	3′·55	6′·20	Mean 5′·23
	Dir......	113°	111°	118°	108°	113°	121°	105°	Mean 113°
	Hours...	21	59	18	130	159	105	120	Sum 612
N.W. to N.	Vel......	3′·85	6′·00	4′·90	3′·93	3′·73	3′·24	5′·02	Mean 4′·26
	Dir......	165°	159°	167°	156°	162°	157°	162°	Mean 161°
	Hours...	20	114	70	15	64	54	43	Sum 380
N. to N.E.	Vel......	5′·15	3′·94	4′·41	3′·33	5′·55	3′·24	6′·03	Mean 4′·52
	Dir......	211°	201°	198°	205°	197°	198°	207°	Mean 202°
	Hours...	57	86	184	36	89	33	67	Sum 552
N.E. to E.	Vel......	7′·91	4′·01	6′·36	8′·35	5′·55	4′·44	10′·34	Mean 6′·71
	Dir......	254°	250°	246°	254°	247°	248°	235°	Mean 248°
	Hours...	171	56	140	101	46	27	97	Sum 638
E. to S.E.	Vel......	8′·75	5′·62	6′·87	8′·10	4′·69	1′·07	9′·25	Mean 6′·32
	Dir......	290°	295°	293°	299°	300°	294°	305°	Mean 297°
	Hours...	183	62	86	75	25	93	20	Sum 544
S.E. to S.	Vel......	13′·49	10′·77	11′·93	9′·76	11′·90	10′·31	14′·27	Mean 11′·66
	Dir......	315°	337°	335°	337°	330°	336°	342°	Mean 332°
	Hours...	97	36	106	86	14	98	18	Sum 455
Maximum		26′	38′	42′	28′	21′·2	30′	33′	......
Hours > 25′		4	1	7	1	0	7	8	Sum 28
Hours of 0		21	19	49	23	3	52	21	Sum 188

TABLE I.—June.

S. to S.W.	Vel......	8′·19	9′·47	12′·32	7′·21	5′·88	7′·73	8′·51	Mean 8′·47
	Dir......	17°	24°	20°	26°	22°	35°	23°	Mean 24°
	Hours...	131	129	49	131	79	142	182	Sum 843
S.W. to W.	Vel......	5′·06	6′·00	7′·67	7′·82	4′·14	6′·96	8′·31	Mean 6′·56
	Dir......	65°	69°	64°	61°	66°	65°	65°	Mean 65°
	Hours...	79	190	92	165	56	193	235	Sum 1010
W. to N.W.	Vel......	5′·87	4′·23	4′·75	5′·07	5′·11	5′·76	4′·54	Mean 5′·05
	Dir......	110°	107°	111°	115°	106°	111°	112°	Mean 110°
	Hours...	31	71	135	97	93	243	71	Sum 741
N.W. to N.	Vel......	3′·76	5′·02	3′·55	3′·47	3′·94	11′·43	4′·91	Mean 5′·75
	Dir......	159°	155°	162°	154°	161°	152°	161°	Mean 158°
	Hours...	58	24	70	88	115	66	62	Sum 483
N. to N.E.	Vel......	4′·76	2′·86	5′·72	5′·15	4′·60	4′·00	3′·48	Mean 4′·29
	Dir......	199°	198°	206°	201°	193°	190°	194°	Mean 197°
	Hours...	65	66	136	33	75	4	88	Sum 467
N.E. to E.	Vel......	7′·94	4′·18	9′·05	8′·12	9′·36	13′·79	4′·24	Mean 6′·67
	Dir......	251°	245°	243°	249°	247°	265°	245°	Mean 249°
	Hours...	125	27	121	56	103	19	25	Sum 476
E. to S.E.	Vel......	5′·36	8′·80	5′·43	8′·03	6′·05	13′·52	6′·61	Mean 7′·58
	Dir......	291°	300°	296°	287°	297°	297°	303°	Mean 296°
	Hours...	137	35	30	60	37	23	13	Sum 335
S.E. to S.	Vel......	9′·65	12′·70	10′·74	10′·06	8′·57	9′·80	11′·15	Mean 10′·28
	Dir......	315°	335°	335°	333°	339°	339°	346°	Mean 335°
	Hours...	88	173	82	85	129	30	33	Sum 620
Maximum		25′	32′	37′	29′	22′	48′	38′	......
Hours > 25′		2	10	4	2	0	18	8	Sum 44
Hours of 0		24	10	15	55	36	10	50	Sum 200

TABLE I.—July.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S.	Vel.......	8′·67	6′·56	7′·79	4′·89	8′·62	10′·53	6′·00	Mean 7′·58
to	Dir.......	33°	24°	27°	29°	31°	27°	19°	Mean 27°
S.W.	Hours...	162	119	135	55	109	122	39	Sum 741
S.W.	Vel.......	7′·83	6′·48	6′·94	4′·59	6′·92	8′·31	5′·19	Mean 6′·61
to	Dir.......	67°	73°	64°	66°	65°	64°	68°	Mean 67°
W.	Hours...	294	191	218	110	213	254	137	Sum 1397
W.	Vel.......	4′·80	5′·05	4′·18	3′·80	4′·29	6′·53	3′·34	Mean 4′·36
to	Dir.......	111°	113°	107°	116°	103°	106°	115°	Mean 110°
N.W.	Hours...	179	120	99	230	99	141	154	Sum 1022
N.W.	Vel.......	5′·05	3′·35	2′·33	2′·85	2′·70	2′·06	3′·51	Mean 3′·03
to	Dir.......	147°	153°	152°	159°	155°	158°	157°	Mean 154°
N.	Hours...	85	139	12	140	17	49	188	Sum 630
N.	Vel.......	4′·45	3′·14	5′·51	3′·07	4′·52	1′·50	4′·24	Mean 3′·71
to	Dir.......	214°	195°	196°	200°	197°	181°	197°	Mean 197°
N.E.	Hours...	33	71	114	78	125	2	112	Sum 535
N.E.	Vel.......	0′	3′·46	7′·19	7′·50	3′·81	18′·5	6′·00	Mean 6′·51
to	Dir.......	......	245°	251°	237°	246°	267°	232°	Mean 246°
E.	Hours...	......	28	108	12	43	2	25	Sum 218
E.	Vel.......	0′	12′·30	4′·69	6′·87	8′·85	11′·95	6′·00	Mean 7′·20
to	Dir.......	......	305°	288°	302°	284°	293°	298°	Mean 295°
S.E.	Hours...	......	23	33	32	67	21	28	Sum 204
S.E.	Vel.......	10′·90	10′·57	12′·91	5′·59	14′·31	11′·10	13′·90	Mean 11′·08
to	Dir.......	356°	341°	336°	332°	252°	341°	344°	Mean 343°
S.	Hours...	5	54	23	93	67	118	33	Sum 393
Maximum		28′	22′	32′	19′	32′	41′	22′	......
Hours > 25′		2	0	2	0	8	20	0	Sum 32
Hours of 0		5	30	15	83	20	33	47	Sum 233

TABLE I.—August.

S.	Vel.......	8′·26	7′·11	9′·85	8′·36	9′·54	7′·14	8′·78	Mean 8′·43
to	Dir.......	24°	17°	28°	30°	26°	28°	28°	Mean 26°
S.W.	Hours...	92	75	174	119	377	202	201	Sum 1240
S.W.	Vel.......	4′·36	6′·01	7′·77	7′·29	7′·50	5′·66	8′·82	Mean 6′·71
to	Dir.......	72°	68°	61°	70°	61°	64°	60°	Mean 65°
W.	Hours...	90	164	242	223	195	195	202	Sum 1311
W.	Vel.......	3′·09	4′·68	5′·83	4′·75	6′·66	3′·21	6′·14	Mean 4′·91
to	Dir.......	119°	115°	104°	108°	101°	116°	115°	Mean 111°
N.W.	Hours...	86	159	153	198	30	93	134	Sum 853
N.W.	Vel.......	3′·52	3′·82	1′·80	3′·39	9′·94	2′·00	6′·26	Mean 4′·29
to	Dir.......	159°	151°	155°	151°	159°	157°	155°	Mean 155°
N.	Hours...	150	52	56	84	18	65	42	Sum 467
N.	Vel.......	4′·71	2′·83	4′·14	5′·54	7′·20	4′·22	7′·65	Mean 5′·16
to	Dir.......	200°	211°	200°	207°	218°	203°	203°	Mean 206°
N.E.	Hours...	124	59	88	31	5	45	32	Sum 384
N.E.	Vel.......	6′·55	3′·78	6′·80	7′·42	9′·77	8′·84	6′·91	Mean 6′·48
to	Dir.......	246°	246°	237°	252°	255°	251°	280°	Mean 252°
E.	Hours...	84	14	5	7	22	13	34	Sum 179
E.	Vel.......	6′·79	6′·55	2′·00	6′·39	12′·14	6′·68	6′·50	Mean 5′·23
to	Dir.......	289°	298°	301°	296°	303°	289°	306°	Mean 297°
S.E.	Hours...	52	70	3	33	14	44	24	Sum 240
S.E.	Vel.......	9′·48	11′·47	8′·80	8′·77	15′·13	10′·93	15′·72	Mean 11′·37
to	Dir.......	337°	333°	344°	341°	340°	335°	334°	Mean 338°
S.	Hours...	46	102	15	40	82	59	36	Sum 380
Maximum		26′	28′	33′	42′	28′	28′	31′	......
Hours > 25′		1	5	1	2	9	6	14	Sum 38
Hours of 0		20	25	28	24	10	39	10	Sum 156

TABLE I.—September.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S.	Vel.......	9′·49	12′·96	10′·64	11′·00	9′·58	9′·05	12′·47	Mean 10′·74
to	Dir.......	22°	18°	21°	21°	26°	25°	31°	Mean 23°
S.W.	Hours...	193	134	204	118	194	190	165	Sum 1198
S.W.	Vel.......	7·′42	8′·12	8′·99	5′·35	6′·50	5′·26	1′·13	Mean 6′·04
to	Dir.......	73°	63	70°	75°	60°	62°	65°	Mean 67°
W.	Hours...	70	296	175	123	66	116	287	Sum 1133
W.	Vel.......	4′·27	5′·12	6′·09	3′·29	4′·67	4′·46	8′·46	Mean 5′·19
to	Dir.......	109°	101°	106°	109°	109°	114°	115°	Mean 108°
N.W.	Hours...	83	59	88	112	142	101	88	Sum 673
N.W.	Vel.......	4′·34	7′·12	4′·00	2′·82	2′·88	3′·77	9′·64	Mean 4′·94
to	Dir.......	164°	160°	155°	156°	163°	157°	159°	Mean 159°
N.	Hours...	75	31	30	88	34	58	54	Sum 370
N.	Vel.......	3′·47	6′·69	5′·17	4′·06	2′·70	3′·88	4′·35	Mean 4′·24
to	Dir.......	200°	199°	204°	205°	170°	193°	193°	Mean 195°
N.E.	Hours...	79	13	62	128	10	78	54	Sum 424
N.E.	Vel.......	3′·30	4′·72	5′·50	4′·85	4′·50	5′·77	5′·00	Mean 4′·64
to	Dir.......	252°	253°	243°	238°	239°	253°	226°	Mean 243°
E.	Hours...	42	102	26	43	2	71	1	Sum 287
E.	Vel.......	23′·55	7′·70	6′·09	4′·53	14′·07	8′·91	13′·50	Mean 11′·05
to	Dir.......	296°	283°	281°	301°	269°	290°	291°	Mean 293°
S.E.	Hours...	26	35	21	29	27	23	8	Sum 169
S.E.	Vel.......	11′·58	13′·75	14′·20	11′·48	12′·61	11′·05	10′·28	Mean 12′·11
to	Dir.......	335°	339°	343°	349°	334°	359°	344°	Mean 343°
S.	Hours...	116	36	82	26	244	66	38	Sum 608
Maximum		34′	32′	36′	36′	42′	29′	39′	......
Hours > 25′		5	6	10	7	27	5	7	Sum 67
Hours of 0.........		32	6	12	27	10	24	7	Sum 118

TABLE I.—October.

S.	Vel.......	8′·02	12′·41	9′·11	12′·40	7′·54	13′·73	9′·50	Mean 10′·33
to	Dir.......	22°	29°	20°	27°	17°	28°	21°	Mean 24°
S.W.	Hours...	130	131	129	166	233	260	136	Sum 1185
S.W.	Vel.......	7′·90	9′·35	5′·12	10′·62	2′·07	13′·60	8′·80	Mean 7′·91
to	Dir.......	59°	66°	73°	71°	67°	61°	66°	Mean 66°
W.	Hours...	149	199	94	263	77	252	298	Sum 1332
W.	Vel.......	6′·17	5′·43	4′·84	6′·46	3′·84	8′·43	5′·76	Mean 5′·85
to	Dir.......	109°	124°	101°	107°	115°	93°	111°	Mean 109°
N.W.	Hours...	100	115	90	115	19	60	37	Sum 536
N.W.	Vel.......	4′·28	2′·05	5′·37	4′·30	1′·45	4′·88	9′·05	Mean 4′·44
to	Dir.......	165°	161°	153°	151°	140°	160°	146°	Mean 154°
N.	Hours...	7	19	46	27	24	9	8	Sum 140
N.	Vel.......	4′·13	5′·25	4′·01	8′·59	2′·65	4′·25	2′·48	Mean 4′·48
to	Dir.......	205°	211°	199°	201°	214°	213°	209°	Mean 207°
N.E.	Hours...	71	167	111	32	43	12	9	Sum 445
N.E.	Vel.......	10′·71	3′·58	5′·45	4′·27	6′·45	3′·65	10′·42	Mean 6′·35
to	Dir.......	253°	240°	245°	235°	238°	250°	252°	Mean 244°
E.	Hours...	82	86	120	27	37	26	80	Sum 458
E.	Vel.......	9′·00	3′·50	4′·81	9′·42	9′·68	5′·16	8′·40	Mean 7′·02
to	Dir.......	281°	286°	290°	314°	299°	280°	290°	Mean 292°
S.E.	Hours...	38	6	95	4	123	25	71	Sum 362
S.E.	Vel.......	11′·43	4′·80	12′·49	14′·70	11′·69	14′·37	13′·12	Mean 11′·61
to	Dir.......	335°	322°	349°	341°	340°	338°	333°	Mean 338°
S.	Hours...	46	20	59	37	165	86	102	Sum 515
Maximum		26′	31′	31′	38′	43′	54′	40′·5	......
Hours > 25′		3	9	5	21	39	60	45	Sum 183°
Hours of 0.........		8	47	27	2	79	8	13	Sum 184

TABLE I.—November.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S. to S.W.	Vel....... Dir....... Hours...	7′·46 19° 200	6′·33 27° 92	12′·81 24° 167	12′·20 23° 83	17′·47 33° 289	8′·73 24° 302	13′·41 21° 242	Mean 11′·25 Mean 24° Sum 1375
S.W. to W.	Vel....... Dir....... Hours...	5′·03 72° 35	5′·49 65° 63	9′·22 66° 140	7′·52 66° 79	14′·24 68° 154	9′·12 60° 122	12′·16 65° 294	Mean 8′·97 Mean 66° Sum 887
W. to N.W.	Vel....... Dir....... Hours...	4′·20 102° 41	7′·49 96° 63	5′·91 115° 87	5′·81 106° 11	4′·25 109° 44	3′·62 111° 35	9′·05 109° 81	Mean 5′·73 Mean 107° Sum 362
N.W. to N.	Vel....... Dir....... Hours...	3′·56 143° 38	2′·32 151° 73	4′·69 153° 42	4′·15 154° 2	4′·77 159° 119	1′·87 159° 16	11′·66 157° 9	Mean 4′·72 Mean 154° Sum 299
N. to N.E.	Vel....... Dir....... Hours...	4′·46 199° 48	6′·32 215° 28	5′·44 212° 38	7′·84 214° 87	3′·54 187° 46	3′·25 204° 31	8′·52 202° 21	Mean 5′·62 Mean 205° Sum 299
N.E. to E.	Vel....... Dir....... Hours...	6′·26 257° 107	8′·45 248° 220	4′·38 255° 31	8′·78 246° 231	11′·25 242° 4	4′·48 246° 27	13′·22 258° 9	Mean 8′·12 Mean 250° Sum 629
E. to S.E.	Vel....... Dir....... Hours...	6′·48 299° 87	8′·48 283° 131	12′·31 277° 79	10′·93 292° 130	9′·66 288° 6	6′·51 293° 47	5′·20 294° 10	Mean 8′·48 Mean 289° Sum 490
S.E. to S.	Vel....... Dir....... Hours...	6′·86 329° 44	15′·05 339° 39	14′·41 337° 99	7′·93 344° 46	6′·04 335° 23	10′·48 342° 127	13′·58 340° 51	Mean 10′·62 Mean 338° Sum 429
Maximum .... Hours > 25′ ...... Hours of 0.........		26′ 6 43	36′ 9 80	37′ 19 37	29′ 5 9	75′ 90 13	37′ 19 54	34′ 30 1	...... Sum 178 Sum 237

TABLE I.—December.

		1857.	1858.	1859.	1860.	1861.	1862.	1863.	
S. to S.W.	Vel....... Dir....... Hours...	26′·11 25° 210	16′·68 26° 230	13′·35 28° 258	6′·78 15° 116	18′·18 20° 121	21′·98 27° 254	16′·52 37° 153	Mean 17′·08 Mean 25° Sum 1342
S.W. to W.	Vel....... Dir....... Hours...	11′·04 69° 175	11′·91 69° 233	8′·41 64° 167	3′·06 60° 78	8′·84 64° 182	14′·13 62° 177	14′·40 62° 335	Mean 10′·20 Mean 64° Sum 1367
W. to N.W.	Vel....... Dir....... Hours...	35′·70 95° 12	10′·98 104° 56	2′·92 113° 26	2′·20 114° 128	5′·44 107° 43	16′·33 109° 90	12′·71 105° 135	Mean 12′·21 Mean 107° Sum 490
N.W. to N.	Vel....... Dir....... Hours...	0′	2′·66 151° 3	3′·38 157° 116	3′·20 159° 38	4′·04 154° 43	13′·96 154° 62	8′·59 155° 32	Mean 5′·09 Mean 155° Sum 294
N. to N.E.	Vel....... Dir....... Hours...	0′	0′	2′·11 203° 36	2′·37 223° 59	4′·38 212° 31	0′	2′·00 212° 1	Mean 1′·55 Mean 212° Sum 127
N.E. to E.	Vel....... Dir....... Hours...	12′·04 254° 3	0′	4′·29 251° 17	5′·40 255° 62	3′·67 258° 56	12′·55 261° 18	3′·50 242° 2	Mean 5′·80 Mean 254° Sum 158
E. to S.E.	Vel....... Dir....... Hours...	0′	17′·20 303° 5	14′·97 295° 37	10′·15 294° 109	6′·86 294° 61	14′·26 290° 64	12′·63 295° 36	Mean 10′·84 Mean 295° Sum 312
S.E. to S.	Vel....... Dir....... Hours...	22′·26 342° 82	21′·95 332° 205	14′·54 334° 84	12′·87 326° 127	14′·24 344° 177	21′·68 340° 57	18′·96 343° 28	Mean 18′·07 Mean 337° Sum 760
Maximum .... Hours > 25′ ...... Hours of 0.........		42′ 81 1	48′ 102 2	45′ 40 60	38′·8 15 56	40′ 56 41	45′ 106 0	50′ 94 0	...... Sum 494 Sum 160

The first thing which strikes one in this Table is the irregularity of the wind. It varies in each octant; in each octant it varies with the month, and in each octant and month it varies with the year. As to the first of these variations, both the velocity of the wind and the number of hours during which it blows are, in general, a maximum in the first octant (S. to S.W.); they decrease from this to a minimum at octants N. to N.E., and increase to octant 1. The products of the velocity and time at the maximum and minimum are as 6 : 1. The predominance of south-westerly winds is what might be expected from the combination of an equatorial current with the earth's rotation; but it is not obvious why it is not absolute. Probably much of the change of direction arises from circumstances local to the place of observation. For instance, the direction of the west coast of Ireland, which runs nearly N. and S., may occasionally turn the S.W. currents northward; and the mountainous ground of Antrim may divert it here towards the east. It must also be remembered that our anemographs give only measure of the wind at the earth's surface, where it is at once retarded and thrown into gigantic eddies and vortices by the effects of friction.

The experience of aeronauts shows that at a few thousand feet elevation the velocity is often far greater than it is below, and that the direction is much more uniform. But I do not see how this error is to be remedied. The summit of a mountain is not exempt from it; and though a small and lofty island, like St. Kilda, far from any extensive land, would be better, yet even here the friction of the sea's surface will destroy velocity. It is possible that an anemograph at the top of a tall and slender "*stack*" would give a much larger velocity than one at its base; the record could be easily effected below by telegraphy. We must remember that a current of air comports itself like one of water, and shall be assisted in comprehending the nature of a gale by watching the irregular movements of a river in flood. There must also be eddies in a vertical plane. On the action of these see a valuable paper by Prof. HENNESSEY in Phil. Trans. 1860. An anemograph for vertical currents might be made by a set of windmill-vanes placed horizontal.

Secondly, in *each* octant the amount of wind varies with the month. It is a maximum in January; decreases from this to July, the ratio being 2¼ : 1. From this it increases to the end of the year. There is an exception to this in March, where the daily amount is greater than in February in the ratio of 1·13 : 1. This might seem to countenance the vulgar notion of stormy weather prevailing near the equinoxes; but there is no such excess in September above October; and in March, though the yearly maxima are higher than in February, yet the number of hours when the velocity exceeds 25 miles is considerably less. This monthly change is an obvious consequence of the change of the sun's declination, for the zone where the easterly winds of low latitudes confine with the westerly ones of more northern regions must shift with that to which the sun is vertical.

For the third of these irregularities, that which prevails from year to year, there can, in the present state of our knowledge, be no certain cause assigned. It will be seen that in the same octants the variation is very different in each month, and that the maxima in each octant do not belong to the same years; while the amount of discordance is so great as to almost exclude the idea of any law. I looked for one in the direction already noticed. In 1860 the sun-spots were at a maximum, in 1856 at a minimum; and if they exert any influence it must have been considerably less in 1857 than in 1860. The products of velocity and time were accordingly examined in these years, and that for 1860 is 4167 greater than in the other. But this result is reversed by 1863, which exceeds 1860 by a still greater amount, 5223; and evidently many decennial periods must be examined before any reliable conclusion can be attained as to this influence.

The same lawless irregularity may be observed in the maximum velocities of separate years. The highest in the period before us is 71 miles in November 1861, the lowest 19, in July 1860. Far higher velocities than these are sometimes attained, but only for a few minutes. It holds also as to the number of hours when the velocity exceeds twenty-five miles. As instances: in January 1863 this number is 146, in 1857 it is 23; in April 1859 it is 40, in 1861 it is 0; in November 1861 it is 90, in 1860 it is 5. It occurs also, though not intensely, in the hours of calm. It may have some interest to give the mean velocity for each month irrespective of the direction.

TABLE II.

Month.	Velocity.	Total miles.
January	13·51	70336
February	12·82	60422
March	13·00	67691
April	11·62	51587
May	7·78	39664
June	4·24	35353
July	6·59	34343
August	7·29	35986
September	8·02	39513
October	9·12	45568
November	9·97	47671
December	12·98	166498

Here also there seems little indication of equinoctial gales. March is a trifle more windy than February, but September less so than October. The yearly sums also do not show any special relation to the solar spots; the total in 1857=79865; in 1860=73067; but in 1863=95583. The total miles in the seven years=590672, and the mean velocity during that time is 9·729.

II. The most obvious way of dealing with the west and south components of V is to derive from them interpolation formulæ for each year involving periodic functions of the time, and deduce from the coefficients of these formulæ in successive years some general law. This, however, seems impracticable, for the components differ so widely in successive years as to preclude any hope of reconciling them. As a specimen of this discordance I give the values for the first hour of the series for January 1:—

1857 . . .	W=12·59	S= 9·81
1858 . . .	− 6·27	22·14
1859 . . .	7·78	6·31
1860 . . .	6·80	20·91
1861 . . .	− 3·91	− 1·21
1862 . . .	1·29	− 2·70
1863 . . .	14·62	22·65

It is evident that here there is no regular succession; and equally so that little dependence can be put on even the mean of the seven as representing the hour 0 for that day. But if, as is probable, these discordances are casual, we may expect they will disappear from the mean of a large number of observations—how large may be estimated from the Probable Error of these observations, though, on account of the magnitude of their discordances, this cannot be determined with great precision. There is also this difficulty in the process of finding the Probable Error, that the coordinates undergo daily and monthly variations, which must not be confounded with the casual errors. It is therefore necessary to confine ourselves to the observations of *each individual* hour during the seven years, and combine any number of these groups of seven. This is effected by the simple means of using as the divisor $n-m$ instead of $n-1$, n being the number of terms in the entire set, and m the number of groups. I have only thought it necessary to make the computation for W in January and June, and I find

P E of a single observation . .	±5·901	±3·913
P E of mean of seven	±2·230	±1·479
P E of W in Table, mean of 217	±0·401	±0·266
P E of mean of month	±0·082	±0·054

The discordancy in summer is only two thirds of that in winter, and in both is so great that the mean of seven is not to be relied on; and even the numbers of Table III. are not sufficiently certain. Perhaps these seven years may have been exceptionally irregular. The discordancy of S is still greater than that of W. Evidently single hours were out of the question; I therefore took for each hour the mean of the month in the first instance; I then grouped these means for every ten days, but ultimately adopted the entire month as the group.

Before discussing these means individually, it may be useful to give their means for the entire period of seven years. Supposing the winter from October to March inclusive, the summer from April to September, the day hours from 7 A.M. to 6 P.M., the night from 7 P.M. to 6 A.M., we find:—

Winter Day.

Sum W=7899^{m}·315; Sum S=11239·92; Ann. Translation=13738; D=35° 6′.

Winter Night.

Sum W=7264^{m}·43; Sum S=11527·75; Ann. Translation=13812; D=33° 25′.

Summer Day.

Sum $W=3519^{m}\cdot 23$; Sum $S=5454\cdot 50$; Ann. Translation$=6491$; $D=32^{\circ}\ 50'$.

Summer Night.

Sum $W=2831^{m}\cdot 43$; Sum $S=5081\cdot 65$; Ann. Translation$=5817$; $D=29^{\circ}\ 8'$.

Both components are more than twice as great in winter as in summer; the day components are greater than the night ones, except the winter S.

The sums of all are Sum $W=21514^{m}\cdot 40$; Sum $S=33303^{m}$; Ann. Trans.$=39648^{m}$; $D=32^{\circ}\ 51'$.

On examining the records of the components, I find that 630 hours were missed by various accidents, so that the total number of hours is 60714; and the above sums, $\times 7^{y}\div 60714^{h}$, will give for the mean hourly values $\overset{1}{W}=2^{m}\cdot 4805$; $\overset{1}{S}=3^{m}\cdot 8398$; $\overset{1}{V}=4^{m}\cdot 5713$; $\overset{1}{D}=32^{\circ}\ 54'\ 44''$. The value of $\overset{1}{V}$ shows that the wind in the first quadrant is nearly half the total amount.

The monthly means of the components are given in the following Table (p. 415).

On examining this Table we observe, *First*, that all the values both of W and S are positive; in other words, that in a considerable number of observations the aerial currents from west and south have at this station a decided predominance over all the others. *Secondly*, that, as was anticipated, however discordant the results of individual hours or days may be, yet the means of from 196 to 217 present a notable agreement, and the differences which they exhibit are evidently subject to law. If we look down the vertical columns (which give approximate values for each hour of the middle day of each month) we find in each a decided maximum and minimum, and another, or even more than one of each, less in amount. The hours of these phases vary with the months; that of the principal maximum occurs in the winter months from noon to 3 P.M. for W; in the summer from 9 A.M. to noon; for S it varies less, being a little before noon.

The principal minimum occurs in the evening, from 6 P.M. to 10 P.M., both for W and S. The extreme diurnal ranges are greatest in March, being for W $2^{m}\cdot 14$, for S $2^{m}\cdot 40$; they are least in November, being 0·74 and 0·79.

It deserves notice that during the winter months the horary values of W for the four afternoon hours exceed those for the four that precede, the sum of the differences being $9^{m}\cdot 95$. In the summer months the reverse is the case, but the $-$ differences are only $7^{m}\cdot 02$.

Does this arise from the great extent of land to the east of Ireland as contrasted with the ocean to its west, and the greater evaporation from the latter in summer?

If we examine the horizontal columns (which show the monthly variations) the dominion of Law is still more manifest. W has a maximum in January, a minimum in February; the greatest maximum is in March, the least minimum in April: these abrupt changes are remarkable; but it is possible that the great value of W in March is abnormal, and may not occur in subsequent years. It then increases with a slight

TABLE III.

Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Hours.
0	W 4·563 S 6·70	W 2·76 S 5·97	W 4·57 S 3·09	W 0·24 S 2·69	W 0·90 S 2·21	W 0·85 S 1·87	W 1·680 S 1·442	W 1·95 S 2·695	W 2·11 S 3·67	W 1·87 S 3·86	W 1·70 S 3·97	W 4·08 S 8·05	0
1	W 4·73 S 6·87	W 3·01 S 5·87	W 4·55 S 3·49	W 0·26 S 3·11	W 0·83 S 2·22	W 0·93 S 1·81	W 1·669 S 1·70	W 1·82 S 2·70	W 2·39 S 3·69	W 1·65 S 4·09	W 2·00 S 4·01	W 4·00 S 7·52	1
2	W 4·59 S 6·89	W 2·81 S 5·84	W 4·81 S 3·61	W 0·40 S 2·865	W 1·06 S 2·22	W 0·91 S 1·93	W 1·912 S 1·581	W 2·00 S 2·66	W 2·23 S 3·48	W 1·85 S 4·12	W 1·81 S 3·76	W 3·99 S 7·615	2
3	W 4·54 S 7·18	W 2·77 S 5·94	W 4·90 S 3·62	W 0·60 S 2·88	W 1·13 S 2·18	W 1·06 S 1·92	W 1·565 S 1·72	W 2·12 S 2·71	W 2·44 S 3·52	W 2·015 S 4·23	W 1·70 S 3·83	W 4·30 S 7·90	3
4	W 4·72 S 7·07	W 2·76 S 6·00	W 4·99 S 3·65	W 0·41 S 2·7	W 1·20 S 2·18	W 1·08 S 2·01	W 1·80 S 1·73	W 2·14 S 2·67	W 2·39 S 3·45	W 2·245 S 4·35	W 1·835 S 3·63	W 4·24 S 8·285	4
5	W 4·47 S 6·66	W 2·59 S 5·88	W 5·00 S 3·43	W 0·47 S 2·79	W 1·12 S 2·285	W 0·99 S 2·01	W 2·18 S 1·81	W 1·93 S 2·90	W 2·55 S 3·53	W 2·13 S 4·36	W 1·84 S 4·11	W 4·32 S 7·78	5
6	W 4·36 S 6·91	W 2·65 S 5·72	W 4·90 S 3·59	W 0·48 S 2·76	W 1·10 S 2·12	W 1·04 S 1·70	W 2·14 S 1·88	W 2·20 S 2·95	W 2·58 S 3·44	W 2·05 S 3·95	W 1·665 S 4·29	W 4·32 S 7·91	6
7	W 3·71 S 6·25	W 2·30 S 6·00	W 4·94 S 3·75	W 0·41 S 2·75	W 0·92 S 2·49	W 1·01 S 1·95	W 2·30 S 1·635	W 2·25 S 2·86	W 2·66 S 3·56	W 1·86 S 3·80	W 1·70 S 4·02	W 4·16 S 7·48	7
8	W 3·88 S 6·53	W 2·52 S 5·94	W 5·17 S 3·73	W 0·70 S 2·94	W 0·79 S 2·30	W 1·02 S 1·88	W 2·65 S 1·63	W 2·25 S 2·72	W 2·565 S 3·79	W 1·70 S 3·42	W 1·72 S 3·97	W 4·00 S 7·44	8
9	W 4·62 S 6·91	W 2·59 S 6·19	W 5·73 S 3·48	W 0·42 S 3·01	W 0·70 S 2·84	W 0·77 S 2·05	W 3·405 S 1·63	W 2·72 S 2·62	W 2·72 S 4·20	W 2·21 S 3·67	W 1·91 S 4·08	W 4·31 S 7·84	9
10	W 4·27 S 7·33	W 3·48 S 6·69	W 6·20 S 3·76	W 0·39 S 3·075	W 0·92 S 2·75	W 1·21 S 2·30	W 3·14 S 1·63	W 3·34 S 3·11	W 2·29 S 4·03	W 2·47 S 3·76	W 1·76 S 4·21	W 3·55 S 7·28	10
11	W 4·51 S 7·22	W 3·94 S 6·53	W 5·05 S 3·62	W 0·52 S 2·26	W 0·55 S 2·57	W 1·05 S 1·99	W 2·50 S 1·88	W 2·98 S 3·19	W 2·29 S 4·32	W 2·52 S 3·97	W 1·495 S 4·27	W 3·92 S 8·14	11
12	W 4·78 S 7·46	W 3·75 S 6·93	W 5·37 S 3·34	W 0·51 S 2·60	W 0·01 S 2·33	W 0·93 S 2·24	W 2·575 S 1·89	W 3·07 S 3·09	W 2·30 S 4·01	W 2·52 S 3·76	W 1·80 S 3·73	W 4·18 S 7·76	12
13	W 4·88 S 7·685	W 4·11 S 6·64	W 5·63 S 2·89	W 0·85 S 2·72	W 0·30 S 2·52	W 1·12 S 2·12	W 2·58 S 1·84	W 3·10 S 2·90	W 2·59 S 3·79	W 2·63 S 3·61	W 2·01 S 4·05	W 4·01 S 7·66	13
14	W 4·91 S 7·02	W 3·87 S 6·11	W 5·62 S 2·62	W 0·87 S 2·67	W 0·10 S 2·32	W 0·82 S 1·97	W 2·59 S 1·63	W 3·15 S 2·85	W 2·645 S 3·83	W 2·42 S 3·67	W 2·16 S 4·12	W 4·34 S 7·44	14
15	W 5·09 S 7·14	W 3·28 S 6·24	W 6·56 S 2·095	W 0·785 S 2·365	W 0·00 S 2·41	W 0·56 S 1·74	W 2·42 S 1·50	W 3·06 S 2·52	W 2·37 S 3·59	W 2·44 S 3·29	W 1·90 S 3·86	W 4·17 S 7·36	15
16	W 4·62 S 6·81	W 3·28 S 5·65	W 6·22 S 1·94	W 0·64 S 1·88	W 0·13 S 2·345	W 0·51 S 1·86	W 2·29 S 1·32	W 2·80 S 2·14	W 2·295 S 3·37	W 2·20 S 3·24	W 1·86 S 3·84	W 4·07 S 7·17	16
17	W 4·39 S 6·87	W 2·38 S 5·27	W 5·85 S 1·79	W 0·76 S 1·65	W 0·39 S 2·15	W 0·53 S 1·32	W 2·37 S 1·43	W 2·35 S 2·235	W 2·12 S 3·07	W 1·83 S 3·47	W 1·58 S 3·72	W 4·11 S 7·29	17
18	W 4·39 S 7·14	W 2·34 S 5·31	W 5·14 S 1·80	W 0·48 S 1·41	W 0·05 S 1·91	W 0·56 S 1·17	W 1·99 S 1·24	W 2·205 S 2·01	W 1·89 S 3·45	W 1·90 S 3·40	W 1·48 S 3·79	W 3·99 S 7·33	18
19	W 4·30 S 6·97	W 2·53 S 5·65	W 4·72 S 2·19	W 0·29 S 1·71	W 0·12 S 1·56	W 0·58 S 1·08	W 1·56 S 0·82	W 1·87 S 1·91	W 1·59 S 3·34	W 1·75 S 3·60	W 1·57 S 4·03	W 4·06 S 7·64	19
20	W 4·62 S 7·44	W 2·59 S 5·53	W 4·48 S 2·51	W 0·04 S 2·03	W 0·20 S 1·62	W 0·73 S 0·89	W 1·38 S 0·85	W 1·64 S 2·05	W 1·75 S 3·68	W 1·885 S 3·835	W 1·42 S 3·95	W 3·86 S 7·83	20
21	W 4·69 S 6·88	W 2·58 S 5·93	W 4·42 S 2·41	W 0·06 S 1·94	W 0·24 S 1·73	W 0·59 S 1·26	W 1·29 S 1·265	W 1·88 S 2·26	W 1·71 S 1·04	W 1·95 S 4·10	W 1·73 S 4·40	W 4·01 S 8·10	21
22	W 5·10 S 6·79	W 2·68 S 6·12	W 4·50 S 2·53	W 0·17 S 2·24	W 0·495 S 1·91	W 0·65 S 1·315	W 1·54 S 1·405	W 1·995 S 2·37	W 1·65 S 4·05	W 2·01 S 4·39	W 1·77 S 4·00	W 3·96 S 8·095	22
23	W 4·81 S 6·99	W 2·34 S 6·46	W 4·65 S 3·20	W 0·34 S 2·24	W 0·81 S 2·12	W 0·685 S 1·58	W 1·625 S 1·29	W 2·00 S 2·72	W 1·93 S 4·12	W 2·04 S 4·07	W 1·69 S 4·11	W 3·77 S 7·80	23

maximum in August and a slight minimum in November. The variation is greater here than in the horary columns, being for hour $15=6^{m}\cdot56$. The largest W is at March $15^{h}=6^{m}\cdot56$; the least at May $15^{h}=0\cdot00$.

The law of S is simpler; it has one maximum in December and one minimum in July; its range, too, is something greater, being in hour $20=6^{m}\cdot98$. The greatest magnitude $=8^{m}\cdot285$ at December 4^{h}, its least $=0^{m}\cdot82$, July 19^{h}. There is a general agreement in the change of the two components, with one striking exception, the maximum and minimum which W has in March and April. Such a general agreement might be expected, for any air coming from the south must have a westward motion due to the greater velocity of the earth's rotation in a southern parallel. This anomaly, if real, may be caused by the geographical conditions to which I have already alluded. To them also may be referred the fact that at May 15^{h} $W=0$, though $S=2^{m}\cdot41$, from which a sensible magnitude of the other might be expected. It must, however, be observed that some of the changes exhibited in this Table can scarcely be regarded as periodical. I have already pointed out that from the very great discordance of individual observations it is evident that a much greater number of them than is afforded by a period of seven years is required to eliminate the barometric and hygrometric influences. Yet these disturbances might be expected to be distributed with some uniformity through the day; while the changes from hour to hour are sometimes considerable. Thus in February 9^{h} to 10^{h} $\Delta W=0\cdot89$; 16^{h} to 17^{h} $\Delta W=-0\cdot90$; March 10^{h} to 11^{h} $\Delta W=-1\cdot15$; 14^{h} to 15^{h} $\Delta W=0\cdot94$; April 10^{h} to 11^{h} $\Delta S=-0\cdot71$; December 10^{h} to 11^{h} $\Delta S=0\cdot86$. These are the largest; and it deserves notice that they occur in winter months; in summer there is much less abruptness of change.

It occurred to me that some of these irregularities might be due to errors in the records of velocity; but this seems quite improbable. Such errors could only arise from three possible causes.

1. Referring to my description of the anemograph in the 'Transactions of the Royal Irish Academy,' vol. xxii., it will be obvious that the track of the recording pencil might be excentric to the brass disk which carries the paper. It was carefully adjusted whenever the clock was cleaned, but was liable to derangement from rough handling. The error which would thus arise was avoided by an easy adjustment, which made the edge of the reading alidad coincide with the right line drawn by the pencil when the clock was wound up. It will easily appear that the readings so made are true.

2. The paper may be excentric to the centre of rotation. Let e be its excentricity, ε that of the pencil, θ the reading of any distance from the winding line, ψ the angle between that line and the line of the two centres, the correction for θ

$$=\frac{-\varepsilon(\sin\psi-1)-(e\sin\psi(-\sin\psi-\theta))}{r},$$

and calling V the change of θ in the following hour,

$$\text{correction of } \mathrm{V}=\frac{2e}{r}\cos\left(\psi-\theta-\tfrac{1}{2}\mathrm{V}\right)\times\sin\tfrac{1}{2}\mathrm{V};$$

supposing $e=0{\cdot}05$ (and such an error is not probable) the maximum error would be $0^{\mathrm{m}}{\cdot}27$. This, therefore, cannot do much harm.

3. A much more serious error may be caused by the rate of the clock which moves the pencils of the instrument. Suppose it a gaining one, the hour-circles on the paper are less than hours, and the recorded Vs belong, not to the times to which they are ascribed, but to periods a little in advance. The error is negligible, except for the hour of winding-up. There the space-curve goes beyond the last hour-circle to a distance equal to the rate in 24^{h}, and the measured V is proportionally too large. If the velocity were uniform, this would be corrected by multiplying $\underset{n}{\mathrm{V}'}$ by $\frac{\mathrm{H}+x}{\mathrm{H}+nx}$, where H is the hour-space, x its hourly increase; but as this seldom is the case, the change must be allowed for by interpolation. In all cases but the last we thus obtain

$$\underset{n}{\mathrm{V}}=\frac{\mathrm{H}+x}{\mathrm{H}}\left\{\underset{n}{\mathrm{V}'}+\left(\underset{n+1}{\mathrm{V}'}-\underset{n}{\mathrm{V}'}\right)\left(\frac{2n-1}{2\mathrm{H}^2}\right)x\right\}.$$

As I never have found $\frac{x}{\mathrm{H}}$ greater than $\frac{1}{45}$, the second term may be neglected, and the coefficient scarcely differs from unity. In the last we have

$$\underset{n}{\mathrm{V}}=\frac{\mathrm{H}+x}{2\mathrm{H}+nx}\left\{\underset{n}{\mathrm{V}'}\times\frac{2\mathrm{H}+x}{\mathrm{H}+nx}+\underset{n+1}{\mathrm{V}'}\times\frac{(n-1)x}{\mathrm{H}}\right\},$$

which may be considerably less than $\overset{1}{\underset{n}{\mathrm{V}}}$. The projection of the space-curve beyond the last hour-circle gives $24x$. This excess occurred most frequently in gales from S.W., and was, I think, often caused by the vibration of the lofty structure which supports the instrument. I have not applied these corrections except in a few cases when the error was glaring. The winding-hour was at 9 A.M. in 1857 and 1858, at 10 A.M. in the other years; and at these hours this influence might be expected; but on comparing their values in Table III. with the formulæ of Tables V. and VI., they seem as well represented as any of the others*.

The discordances of these quantities would have been less striking had they been grouped as three-hourly means; and this was my original intention, which I abandoned on account of a difficulty in respect of interpolation to which I will refer presently.

It is, however, necessary to remark that the numbers of Table III. are merely *probable* values. A sensible proportion of the individual values is invariably negative for each hour; and my first idea was to keep the positive and *negative* means separate. I tried it for January and June as extreme cases, and came to the conclusion that this separation would be useless. The negative values occur so constantly, that they can scarcely be deemed casual. In the 744 septimates of January there are only seven in which all the W and S are positive; in the 720 of June there are none.

---

* I have given these details as they will be useful in case it be ever thought desirable to reduce the entire series of their anemograms, which extends from 1847 to 1870.

It might be expected, from the mechanism of the polar and equatorial currents, that both components would change signs simultaneously; but it is not so. I find that the proportion of the combinations is:—

In January . . $\begin{smallmatrix}W+\\S+\end{smallmatrix}0{\cdot}589$; $\begin{smallmatrix}W+\\S-\end{smallmatrix}0{\cdot}141$; $\begin{smallmatrix}W-\\S+\end{smallmatrix}0{\cdot}184$; $\begin{smallmatrix}W-\\S-\end{smallmatrix}0{\cdot}086$.
In June . . . „ 0·406; „ 0·220; „ 0·198; „ 0·176.

The combination of +W with −S may arise from the influence of a continent to the east of Ireland, and that of −W and +S from a north-east current whose north component has been destroyed by friction; but I looked for a greater frequency of −W and −S. If we confine ourselves to consider +W, −W, +S, and −S separately, we find:—

For January . . . Sum (+W)=32121; Sum (−W)=−8315;
Sum (+S) =42733; Sum (−S) =−6372.
For June . . . . Sum (+W)=13298; Sum (−W)=−9002;
Sum (+S) =15978; Sum (−S) =−7163.

The amount of negative components does not differ very much in the two months, but that of the positive is nearly triple in January what it is in June. Were we to attempt to develop separately these + and − values, we should be embarrassed by the different numbers of them belonging to each hour. Thus in January the number for −W is 47 at 2^h, 69 at 11^h; for −S is 41 at 2^h, 56 at 1^h. In June, for −W it is 63 at 3^h, 91 at 15^h; for −S it is 65 at 2^h, 98 at 9^h. Supposing them developed in terms of the time, we should still be unable to obtain any *absolute* values of the components at a given epoch unless we knew the causes which produce these negative values and the laws of their action. It is evident that the equatorial current predominates here, but that there coexists with it a polar one, probably above, possibly collateral, which is occasionally mixed with the other by some disturbing force—probably barometric. It seems also that the monthly variation of the components is in a great measure limited to the positive values. For these reasons I have confined myself to the simple means of the entire set. But I think it might be well, in a series extending to several periods of five or seven years, to keep them so far separate as to be able to examine whether the occurrence of the negative values has any relation to time.

A Table like this, whose data refer to dates separated by considerable intervals, will not suffice to give the components generally without some process of interpolation; and we proceed to consider this. The form universally adopted where the quantities concerned are periodic functions of the time-angle is that given by BESSEL, in which, calling the quantity u and the angle θ, we have

$$\begin{aligned} u= & \mathrm{K}+\mathrm{A}\cos\theta+\mathrm{B}\cos 2\theta+\mathrm{C}\cos 3\theta+\mathrm{D}\cos 4\theta+\&c. \\ & +\mathrm{O}\sin\theta+\mathrm{P}\sin 2\theta+\mathrm{R}\sin 3\theta+\mathrm{S}\sin 4\theta+\&c. \end{aligned}$$

But as the monthly variations must be represented as well as the horary, a formula of this nature including two variables would be very complicated; and it seems best to obtain, as proposed by BESSEL, the horary formula for each month, and to regard the constants of this formula as themselves periodic functions of the monthly time, and develop them in similar formulas of the month-angle, ϕ. Stopping at terms of the fourth order, we should have nine of these for each component; and for a given day of the year and hour of the day we must compute the constants for the ϕ of the day, and multiply each of the last eight by the cosine or sign of the corresponding multiple of θ. The calculation of the horary constants is shortened by observing that for the angles θ, $180+\theta$, $180-\theta$, and $360-\theta$ the sines and cosines have the same numerical value; and hence the calculation need only be made for the first quadrant.

Supposing the circle divided into $2n$ equal parts, and that θ contains m of these, the u corresponding to any θ may be characterized as u_{m}, that corresponding to $\theta+180$ as u_{n+m}, and the sum or difference of these two as s_{m}, d_{m}.

As the cosines and sines of odd multiples of θ and $180+\theta$ differ in sign, but those of even multiples agree, the expressions of A, O, C, and R will contain only d, those of the others only s. The signs of s_{m} and d_{m} are easily determined in each case. Thus for the first multiples of θ the cosine and sine are + for m through the entire quadrant; they are — and + for $n-m$. For the second multiples the sine is + through the quadrant, the cosine is + up to 45°, — through the rest; for $n-m$ the cosine is the same as for m, the sine different. I take, as in the first instance, the horary division in which $n=12$, and BESSEL'S formulæ become

$$\mathrm{K}=\tfrac{1}{24}\left\{s_{0}+s_{1}+s_{2}\ldots\ldots+s_{11}\right\},$$

$$\mathrm{A}=\tfrac{1}{12}\left\{d_{0}+\left(d_{1}-d_{11}\right)\cos 15^{\circ}+\left(d_{2}-d_{10}\right)\cos 30^{\circ}+\left(d_{3}-d_{9}\right)\cos 45^{\circ}+\tfrac{1}{2}\left(d_{4}-d_{8}\right)+\left(d_{5}-d_{7}\right)\cos 75^{\circ}\right\},$$

$$\mathrm{B}=\tfrac{1}{12}\left\{s_{0}-s_{6}+\tfrac{1}{2}\left(s_{2}+s_{10}-s_{4}-s_{8}\right)+\left(s_{1}+s_{11}-s_{5}-s_{7}\right)\cos 30^{\circ}\right\},$$

$$\mathrm{C}=\tfrac{1}{12}\left\{d_{0}-\tfrac{1}{2}\left(d_{4}-d_{8}\right)+\left[d_{1}-d_{11}-\left(d_{3}-d_{9}+d_{5}-d_{7}\right)\right]\sin 45^{\circ}\right\},$$

$$\mathrm{D}=\tfrac{1}{12}\left\{s_{0}+s_{6}+\tfrac{1}{2}\left(s_{1}+s_{11}\right)-\tfrac{1}{2}\left(s_{2}+s_{10}\right)-\left(s_{3}+s_{9}\right)-\tfrac{1}{2}\left(s_{4}+s_{8}\right)+\tfrac{1}{2}\left(s_{5}+s_{7}\right)\right\},$$

$$\mathrm{O}=\tfrac{1}{12}\left\{\left(d_{1}+d_{11}\right)\sin 15^{\circ}+\tfrac{1}{2}\left(d_{2}+d_{10}\right)+\left(d_{3}+d_{9}\right)\sin 45^{\circ}+\left(d_{4}+d_{8}\right)\sin 60^{\circ}+\left(d_{5}+d_{7}\right)\sin 75^{\circ}+d_{6}\right\},$$

$$\mathrm{P}=\tfrac{1}{12}\left\{\tfrac{1}{2}\left(s_{1}-s_{11}+s_{5}-s_{7}\right)+s_{3}-s_{9}+\left(s_{2}-s_{10}+s_{4}-s_{8}\right)\cos 30^{\circ}\right\},$$

$$R=\tfrac{1}{12}\left\{d_2+d_{10}-d_6+\left(d_1+d_{11}+d_3+d_9-d_5-d_7\right)\cos 45^\circ\right\},$$

$$S=\tfrac{1}{12}\left\{s_1-s_{11}+s_2-s_{10}-\left(s_4-s_8+s_5-s_7\right)\cos 30^\circ\right\},$$

and so on.

These are all combinations of the groups $s_m \pm s_{n-m}$, $d_m \pm d_{n-m}$; and by forming these groups the computation is evidently much simplified.

This simplification is, however, only possible when n is an integer, and a the first arc of the series$=\frac{\pi}{2n}$ or$=0$.

Whatever be the value of a, BESSEL'S formula fails generally to give G and U the cosine- and sine-coefficients of the nth order. The θ_m correspond to $u_m=a+(m-1)\frac{\pi}{n}$, and this for the order p becomes $pa+p(m-1)\frac{\pi}{n}$. Then cosine $\theta_m=\cos(na)$, sin $\theta_m=$sine na; both + for odd values of m, — for even ones. Thence the nth coefficient—

$$\begin{aligned} u_1\cos na&=\mathrm{K}\cos na+\&c.+\mathrm{G}\cos^2 na+\mathrm{U}\sin na\cos na,\\ -u_2\cos na&=-\mathrm{K}\cos na-\&c.+\mathrm{G}\cos^2 na+\mathrm{U}\sin na\cos na.\end{aligned}$$

Then summing from $m=1$ to $m=2n$, we get

$$\cos na\ \mathrm{S}\left(u_1-u_2\right)=(\cos^2 na\ \mathrm{G}+\sin na\cos na\ \mathrm{U})\times 2n,$$

$$\mathrm{S}\left(u_1-u_2\right)=2n\,(\mathrm{G}\cos na+\mathrm{U}\sin na).$$

Here the divisor of $\mathrm{S}\left(u_1-u_2\right)$ is $2n$ instead of n; and these coefficients cannot be obtained separately unless $a=0$ or $\frac{\pi}{2n}$, in which case the cosine or sine $=0$.

How far the series is to be continued depends on the periodic fluctuations of the us, and may be found by trial, or by BESSEL'S expression for the squares of the residual errors. In any case it should not be carried further than the order $\frac{\pi}{2a}$, as after that the coefficients coalesce. BESSEL has shown this for $a=0$; and it can easily be proved to hold good when a is a submultiple of $\frac{\pi}{2}$ and b a multiple of a.

For the horary groups I find the fourth order sufficient. These horary groups might be combined in triple sets; but, as I have said, there is a difficulty in the interpolation due to the fact that while u'_θ, the mean of any three, is multiplied by cosine or sine of θ, the first and third components of it should be multiplied by the same functions of $\theta-b$ and $\theta+b$. This, however, may easily be corrected. Take the case of A: the effect of three components to determine this is:—

$$u_{-b}\times\cos(\theta-b)+u_{\theta}+u_{\theta+b}\times\cos(\theta+b)=u_{\theta-b}\cos\theta\cos b+u_{\theta}+u_{\theta+b}\cos\theta\cos b-\left(u_{\theta+b}-u_{\theta-b}\right)\sin\theta\sin b$$

$$=\left(u_{\theta-b}+u_{\theta}+u_{\theta+b}\right)\cos\theta-\left(u_{\theta+b}+u_{\theta-b}\right)\cos\theta\text{ versine }b-\left(u_{\theta+b}-u_{\theta-b}\right)\sin\theta\sin b.$$

Developing the sum and difference of the *u*s, which gives

$$u_{\theta+b}+u_{\theta-b}=2\mathrm{K}+2\mathrm{A}\cos\theta\cos b+2\mathrm{O}\sin\theta\cos b+2\mathrm{B}\cos 2\theta\cos 2b+\&c.,$$

$$u_{\theta+b}-u_{\theta-b}=-2\mathrm{A}\sin\theta\sin b+2\mathrm{O}\cos\theta\sin b-2\mathrm{B}\sin 2\theta\sin 2b\ \&c.,$$

we obtain the term

$$=3\acute{u}\cos\theta-2\text{ versine }b\{\mathrm{K}\cos\theta+\mathrm{A}\cos^2\theta+\mathrm{O}\sin\theta\cos\theta+\&c.\}$$

$$+2\sin^2 b\{\mathrm{A}\sin^2\theta+\mathrm{O}\sin\theta\cos\theta+\&c.\}.$$

Summing round the circle, calling $\mathrm{S}u'\cos\theta=\mathrm{F}$, and remembering that all except $\mathrm{S}\cos^2\theta$ and $\mathrm{S}\sin^2\theta$ vanish, that each of these $=4$, and $12\mathrm{A}=3\mathrm{F}$ in ordinary cases, we have

$$12\mathrm{A}=3\mathrm{F}-8\mathrm{A}\text{ cos versine }b+8\mathrm{A}\sin^2 b,$$

and ultimately

$$\mathrm{A}\times 4\left(1-\tfrac{2}{3}\text{ versine }b\right)=\mathrm{F}.$$

O is given by the same formula, changing the cosines for sines in F. For higher orders, P, it is only necessary to use $p\theta$ and pb. In the case of D, however, the formula must be modified; for in this instance $\mathrm{S}\cos^2=8$, $\mathrm{S}\sin^2=0$, and the expression is $\mathrm{D}\left(4+\tfrac{16}{3}\text{ cos versine }4b\right)=\mathrm{F}$. The values of the constants are:—

$\mathrm{A}\,(3{\cdot}9091)=d_0+\left(d_3-d_9\right)\sin 45^\circ.$

$\mathrm{B}\,(3{\cdot}6428)=s_0-s_6.$

$\mathrm{C}\,(3{\cdot}2190)=d_0-\left(d_3-d_9\right)\sin 45^\circ.$

$\mathrm{D}\,(5{\cdot}333)\ =s_0+s_6-\left(s_3+s_9\right).$

$\mathrm{O}\,(3{\cdot}9091)=d_6+\left(d_3+d_9\right)\sin 45^\circ.$

$\mathrm{P}\,(3{\cdot}6428)=s_3-s_9.$

$\mathrm{R}\,(3{\cdot}2190)=-d_6+\left(d_3+d_9\right)\sin 45^\circ.$

$\mathrm{S}\qquad\qquad=0.$

The suffixes here are the same as in the preceding formulæ. Thus θ_3 is 45°, θ_6 is 90°.

I have compared this formula with the observations of February and March, the most irregular of the whole set, and the results, along with those of the preceding one, are given in the following Table. The numbers are the observed —the calculated values.

TABLE IV.

Hours.	February.		March.	
	Normal.	Triplet.	Normal.	Triplet.
	m	m	m	m
0	0·07	0·02	0·02	0·00
1	0·22	0·26	0·02	−0·20
2	−0·03	0·04	−0·07	−0·12
3	−0·11	−0·04	−0·07	−0·06
4	−0·02	0·08	−0·11	0·16
5	−0·03	0·02	−0·18	0·29
6	0·21	0·17	−0·07	0·04
7	−0·17	−0·18	0·01	−0·30
8	0·00	0·08	−0·30	−0·52
9	−0·24	−0·23	0·01	−0·15
10	0·11	0·25	0·38	0·57
11	0·21	0·28	−0·48	−0·29
12	−0·28	−0·26	−0·02	0·15
13	0·04	0·00	0·21	0·15
14	0·01	−0·08	−0·17	−0·32
15	−0·12	−0·25	0·28	0·31
16	0·34	0·38	−0·20	−0·01
17	−0·23	−0·13	0·05	0·01
18	−0·11	0·11	−0·05	−0·05
19	0·07	0·15	0·16	−0·03
20	0·07	0·19	−0·05	−0·06
21	0·00	−0·06	−0·09	−0·08
22	0·11	−0·03	−0·07	−0·17
23	−0·25	−0·26	0·06	−0·22
P E	±0·110	±0·123	±0·123	±0·161

The triplet combinations are not much inferior to the others, and might possibly be sufficient; but I prefer the latter. Even in the extreme cases of February 16 and March 8, 10^{h} and 11^{h}, the discordance is not as great as I anticipated from the absence of the constant S. I tried them, omitting the terms of the fourth order, but the results were decidedly inferior.

In considering the magnitude of some of these errors, it must be remembered that the formula expresses only that part of the coordinates which is periodic; and they are the residues of other effects which do not depend on the time θ, and which disappear from a larger series of observations; for the other hours the errors are much smaller. I thought of grouping the hours in pairs, which would probably have given a better result than the triple combination; but on deducing the formula, I found it would require more logarithmic work than the complete process. In it the coefficient of a constant of the p order has the coefficient $= 6 \cos p \times 15°$, instead of 6, as is evident from what precedes.

The horary constants of W for the twelve months are given in

TABLE V.

Month.	K.	A.	B.	C.	D.	O.	P.	R.	S.
January ...	4·571	0·058	0·234	−0·104	−0·115	−0·211	0·133	−0·126	−0·080
February...	2·913	−0·474	0·457	−0·199	−0·010	−0·048	0·219	−0·046	0·021
March......	5·165	−0·645	−0·043	0·244	−0·202	−0·108	0·272	0·072	−0·183
April	0·462	−0·212	−0·016	0·089	−0·000	0·008	0·081	−0·024	0·086
May	0·594	0·161	0·044	0·098	0·021	0·458	0·127	0·055	−0·066
June	0·837	−0·052	0·080	−0·090	0·004	0·252	0·021	0·026	0·037
July.........	2·104	−0·651	0·052	0·197	−0·046	0·225	−0·033	0·104	−0·043
August ...	2·367	−0·630	0·228	0·031	−0·114	−0·012	0·115	−0·005	−0·105
September.	2·252	−0·236	0·011	0·105	−0·018	0·203	0·122	−0·053	0·067
October ...	2·090	−0·274	0·159	−0·131	−0·040	0·049	0·074	−0·085	−0·123
November..	1·754	−0·084	0·094	0·044	−0·068	0·046	0·112	−0·082	0·040
December..	4·071	−0·023	−0·083	−0·015	−0·003	0·103	0·127	0·006	0·032

The similar constants of S are given in

TABLE VI.

Month.	K′.	A′.	B′.	C′.	D′.	O′.	P′.	R′.	S′.
January ...	6·982	−0·131	0·170	−0·252	−0·002	−0·143	0·049	0·089	−0·007
February...	6·017	−0·239	0·419	−0·108	−0·012	0·160	−0·085	−0·109	−0·085
March......	2·976	0·012	0·311	−0·080	−0·012	0·944	−0·155	−0·009	0·058
April	2·472	−0·026	0·248	0·053	−0·112	0·561	0·070	−0·037	0·137
May	2·221	−0·252	0·142	0·142	−0·054	0·226	0·054	−0·042	−0·077
June	1·749	−0·237	0·139	0·043	−0·015	0·379	0·155	−0·006	−0·054
July	1·539	−0·150	0·120	−0·015	0·080	0·287	0·124	−0·048	−0·007
August ...	2·621	−0·176	0·241	−0·033	0·089	0·354	0·116	−0·078	−0·123
September.	3·715	−0·093	0·284	−0·037	−0·086	0·071	−0·259	−0·030	−0·057
October ...	3·834	0·289	0·104	−0·202	−0·018	0·217	−0·033	−0·072	−0·081
November..	3·990	−0·041	0·038	−0·013	0·006	0·081	−0·145	−0·060	0·001
December..	7·696	0·181	0·102	−0·214	−0·006	0·121	−0·100	−0·093	−0·087

The degree of precision with which these constants represent the observations will appear from the number of errors between certain limits. W has from 0·0 to 0·10 inclusive, 177; from 0·11 to 0·20, 72; from 0·21 to 0·30, 33; from 0·31 to 0·40, 3; above 0·40, 3. S has from 0·00 to 0·10, 172; from 0·11 to 0·20, 85; from 0·21 to 0·30, 27; from 0·31 to 0·40, 3; above 0·40, 1.

We now proceed to develop these constants in terms of ϕ; but as four orders do not give K and K′ with sufficient exactness, I have carried the formula to the sixth order, its utmost extent.

Formula where $b=30°$ and $a=15°$.

$$6\mathrm{A}=(d_1-d_6)\cos 15+(d_2-d_5)\cos 45+(d_3-d_4)\cos 75.$$

$$6\mathrm{O}=(d_1+d_6)\sin 15+(d_2+d_5)\sin 45+(d_3+d_4)\sin 75.$$

$$6\mathrm{B}=\{s_1+s_6-(s_3+s_4)\}\cos 30.$$

$$6\mathrm{P}=\tfrac{1}{2}\{s_1-s_6+s_3-s_4\}+s_2-s_5.$$

$$6\mathrm{C}=\{d_1-d_6-(d_2-d_5+d_3-d_4)\}\cos 45.$$

$$6\mathrm{R}=\{d_1+d_6+d_2+d_5-(d_3+d_4)\}\sin 45.$$

$$6\mathrm{D}=\tfrac{1}{2}\{s_1+s_6+s_3+s_4\}-(s_2+s_5).$$

$$6\mathrm{S}=\{s_1-s_6-(s_3-s_4)\}\cos 30°.$$

$$6\mathrm{E}=(d_1-d_6)\sin 15°-(d_2-d_5)\cos 45°+(d_3-d_4)\cos 15°.$$

$$6\mathrm{T}=(d_1+d_6)\cos 15°-(d_2+d_5)\cos 45+(d_3+d_4)\sin 15.$$

$$12\mathrm{U}=s_1-s_6-(s_2-s_5)+s_3-s_4.$$

G, for reasons already given, cannot be determined.

It is, however, necessary to obviate two difficulties which interfere in the present instance with the accuracy of this process, but which do not affect the horary interpolation. It supposes that the us employed represent values of the coordinates belonging to dates which correspond with a series of ϕ in arithmetical progression.

This is not the case; for (1) the means of each month do not represent exactly the coordinates belonging to the middle of that month; and (2) the angles representing the distance of the middle of each month from the beginning of each year are not in arithmetical progression, as is evident from the following Table, which gives these angles $=\psi$, and also those belonging to each half month$=\mu$.

TABLE VII.

Month.	ψ.	μ.	Month.	ψ.	μ.
January	15° 16′·5	15° 16′·8	July	193° 40′·8	15° 16′·8
February	44 21·2	13 53·4	August	224 13·8	15 16·8
March	73 25·9	15 16·8	September	254 18·0	14 46·6
April	103 25·2	14 46·6	October	284 24·6	15 16·8
May	133 33·6	15 16·8	November	314 25·2	14 46·6
June	163 37·2	14 46·6	December	344 28·8	15 16·8

Both these difficulties are overcome by a process based on a suggestion of Professor STOKES.

Let the true constants of the formula be denoted by small *italic* letters, so that

$$\underset{1}{u}=\mathrm{K}+a\cos\theta+o\sin\theta+b\cos 2\theta+\&\mathrm{c}.,$$

then, as the mean of u through the space $\theta'-\theta=\int_\theta^{\theta'}ud\theta$, we have

$$\text{mean } u=\left\{\int\mathrm{K}d\theta+\int a\cos\theta d\theta+\int o\sin\theta d\theta\ \&\mathrm{c}.\right\}\frac{1}{\theta'-\theta}.$$

Let $\theta'=\psi+\mu$, $\theta=\psi-\mu$; and as all the pairs of terms are of the same form,

$$\underset{p}{a}\cos p\theta+\underset{p}{o}\sin p\theta,$$

integrating this will do for all. The integral is

$$\mathrm{K}\theta+\ldots\ldots+\underset{p}{a}\frac{\sin p\theta}{p}-\underset{p}{o}\frac{\cos p\theta}{p},$$

which within the limits

$$=\mathrm{K}2\mu\ldots\ldots+\underset{p}{a}\left\{\frac{\sin(p\psi+p\mu)}{p}-\sin\frac{(p\psi-p\mu)}{p}\right\}-\underset{p}{o}\left\{\frac{\cos(p\psi+p\mu)}{p}-\frac{\cos(p\psi-p\mu)}{p}\right\}$$

$$=2\mathrm{K}\mu+\frac{2\underset{p}{a}\cos p\psi\sin p\mu+2\,o\sin p\psi\sin p\mu}{p\mu\div\sin p\mu};$$

and dividing by $2\mu=\theta'-\theta$, we obtain, calling $\frac{p\mu}{\sin p\mu}=\underset{p}{r}$,

$$\text{mean } u=\mathrm{K}+a\frac{\cos\psi}{r}+\frac{o\sin\psi}{r}+b\frac{\cos 2\psi}{\underset{2}{r}}+\&\mathrm{c}.$$

Now we might form the n equations for u and treat them by minimum squares; but as in this case none of the terms would vanish on summing, though all (except the one, say $\underset{p}{a}$, whose square appears) are small, the labour of eliminating 12 quantities 13 times over would be truly formidable. This might be evaded by substituting in each sum for the true constants those given by the series of ϕ, which differ little from them, and all, except $\underset{p}{\mathrm{A}}$, are multiplied by small coefficients. This will give $\Delta\underset{p}{a}$ with close approximation. The process may be repeated with the corrected values, but $\Delta\underset{p}{a}$ alone will have any notable effect. Yet even with this simplification the labour is very great. But it may be superseded thus. We have the above equation for $\underset{1}{u}$; but we have also $u'=\mathrm{K}+\mathrm{A}\cos\phi+\mathrm{O}\sin\phi+\mathrm{B}\cos 2\phi+\mathrm{P}\sin 2\phi$ &c.; and equating the two values,

$$\mathrm{K}+\frac{a\cos\psi}{r}+\frac{o\sin\psi}{r}+\frac{b\cos 2\psi}{\underset{2}{r}}+\frac{p\sin 2\psi}{\underset{2}{r}}=\mathrm{K}+\mathrm{A}\cos\phi+\mathrm{O}\sin\phi+\&\mathrm{c}.$$

It is evident that if we put $a=\mathrm{A}\frac{r\cos\phi}{\cos\psi}$, $o=\mathrm{O}\frac{r\sin\phi}{\sin\psi}$, and so on, the equation would be satisfied, if the factors $\frac{r\cos\phi}{\cos\psi}$, $\frac{r\sin\phi}{\sin\psi}$ &c. were equal in every month. They, however, differ so little that I have thought it lawful to take their means for the twelve months.

Though this is fairly warranted, yet it seemed advisable to test it by comparing for E the cosine constant, of the fifth order in the series for K, with the minimum square process. It gives for E 1·0525; the second approximation, using ΔE alone, gives 1·0305, which would be a little increased by using the corrections of the other constants, so that the agreement is sufficient. As the factors $r_p \frac{\cos p\phi}{\cos p\psi}$, $r_p \frac{\sin p\phi}{\sin p\psi}$ will answer for any year, I give their logarithms.

A.	O.	B.	P.	C.	R.
0·00672	0·00346	0·02156	0·02119	0·04411	0·04976
D.	**S.**	**E.**	**T.**	**G.**	**U.**
0·09300	0·08400	0·16622	0·11988	Not determined.	0·19731

It does not seem necessary to give the constants A, O, &c.; but instead the secondary constants of the formula $u_\theta = K_0 + K_1 \sin(r+\theta_1) + K_2 \sin(r+2\theta_2) +$ &c., deduced from their corrected values, are given as more convenient for computation in Table VIII. (p. 427).

I have given the constants for the horary coefficients A, O, &c. to the 6th order for symmetry; but in fact I do not think any of them less than 0·05 need be attended to. Even this limit is beyond what can be expected to be available when they are only determined by the observations of seven years, as is evident from what I have already said as to the P E of the quantities from which they are determined. Whether the diurnal variation of the coordinates follows the same law in different septennial periods remains to be determined; probably it does. The constants belonging to K_ϕ and K'_ϕ are larger than the others, and, as derived from larger coefficients, merit more confidence.

The effect of the terms of the first and second orders, which are the chief, are similar but the others present opposite phases, and would probably be modified by more accurate determination. It is here that I think changes in successive years will probably be found; and were I to pursue this work further, I would combine the observations rather differently from what I have done in the present case. I would mean the homonymous hours of each month of each year, combine them in pairs, and mean *them* to get the K of each month. I would then compute the K constants, retaining the cosine and sine form; and this should be continued through a few periods of the solar spots. This would decide the question whether the wind is affected by the conditions which modify those phenomena.

At the same time the inspection of the horary means would show whether *their* laws vary with the time. Then the final constants could be determined for such intervals as might be considered sufficient. The sine and cosine formula, though requiring more

TABLE VIII.

$K_0=2\cdot4307$	$K_1=1\cdot3393$ $\varkappa_1=85^\circ 37'\cdot4$	$K_2=1\cdot1203$ $\varkappa_2=12^\circ 37'\cdot7$	$K_3=0\cdot3354$ $\varkappa_3=191^\circ 24'\cdot2$	$K_4=0\cdot8488$ $\varkappa_4=130^\circ 9'\cdot3$	$K_5=1\cdot1377$ $\varkappa_5=89^\circ 43'\cdot3$	$K_6=0\cdot4856$ $\varkappa_6=0^\circ 0'\cdot0$
$A_0=-0\cdot2552$	$A_1=0\cdot1601$ $\alpha_1=33^\circ 21'\cdot2$	$A_2=0\cdot3159$ $\alpha_2=159^\circ 44'\cdot6$	$A_3=0\cdot1927$ $\alpha_3=60^\circ 9'\cdot0$	$A_4=0\cdot0215$ $\alpha_4=179^\circ 22'\cdot9$	$A_5=0\cdot1235$ $\alpha_5=333^\circ 51'\cdot8$	$A_6=0\cdot0351$ $\alpha_6=0^\circ 0'\cdot0$
$B_0=0\cdot1014$	$B_1=0\cdot0419$ $\beta_1=91^\circ 14'\cdot5$	$B_2=0\cdot1090$ $\beta_2=13^\circ 56'\cdot5$	$B_3=0\cdot9878$ $\beta_3=333^\circ 23'\cdot7$	$B_4=0\cdot1551$ $\beta_4=301^\circ 45'\cdot1$	$B_5=0\cdot0413$ $\beta_5=330^\circ 51'\cdot9$	$B_6=0\cdot0569$ $\beta_6=180^\circ 0'\cdot0$
$C_0=0\cdot0224$	$C_1=0\cdot0299$ $\gamma_1=314^\circ 21'\cdot1$	$C_2=0\cdot0485$ $\gamma_2=266^\circ 47'\cdot5$	$C_3=0\cdot1202$ $\gamma_3=171^\circ 26'\cdot1$	$C_4=0\cdot0427$ $\gamma_4=216^\circ 34'\cdot8$	$C_5=0\cdot0387$ $\gamma_5=153^\circ 44'\cdot8$	$C_6=0\cdot1180$ $\gamma_6=0^\circ 0'\cdot0$
$D_0=-0\cdot0492$	$D_1=0\cdot0207$ $\delta_1=261^\circ 18'\cdot7$	$D_2=0\cdot0628$ $\delta_2=167^\circ 0'\cdot0$	$D_3=0\cdot0399$ $\delta_3=25^\circ 31'\cdot2$	$D_4=0\cdot0087$ $\delta_4=291^\circ 22'\cdot8$	$D_5=0\cdot0830$ $\delta_5=229^\circ 34'\cdot7$	$D_6=0\cdot0348$ $\delta_6=180^\circ 0'\cdot0$
$O_0=0\cdot0804$	$O_1=0\cdot1630$ $o_1=261^\circ 11'\cdot8$	$O_2=0\cdot1296$ $o_2=165^\circ 16' 3$	$O_3=0\cdot0597$ $o_3=16^\circ 34'\cdot7$	$O_4=0\cdot0776$ $o_4=209^\circ 43'\cdot0$	$O_5=0\cdot1591$ $o_5=189^\circ 21'\cdot5$	$O_6=0\cdot0342$ $o_6=0^\circ 0'\cdot0$
$P_0=0\cdot1142$	$P_1=0\cdot0650$ $\varpi_1=55^\circ 28'\cdot5$	$P_2=0\cdot0565$ $\varpi_2=306^\circ 8'\cdot2$	$P_3=0\cdot0069$ $\varpi_3=48^\circ 33'\cdot1$	$P_4=0\cdot0626$ $\varpi_4=215^\circ 38'\cdot0$	$P_5=0\cdot0339$ $\varpi_5=46^\circ 45'\cdot1$	$P_6=0\cdot0126$ $\varpi_6=0^\circ 0'\cdot0$
$R_0=-0\cdot0095$	$R_1=0\cdot0209$ $\rho_1=298^\circ 39'\cdot9$	$R_2=0\cdot0205$ $\rho_2=74^\circ 20'\cdot1$	$R_3=0\cdot0430$ $\rho_3=204^\circ 6'\cdot5$	$R_4=0\cdot0276$ $\rho_4=152^\circ 52'\cdot7$	$R_5=0\cdot0621$ $\rho_5=148^\circ 23'\cdot7$	$R_6=0\cdot0186$ $\rho_6=0^\circ 0'\cdot0$
$S_0=-0\cdot0264$	$S_1=0\cdot0035$ $\sigma_1=166^\circ 20'\cdot3$	$S_2=0\cdot0339$ $\sigma_2=156^\circ 5'\cdot1$	$S_3=0\cdot0245$ $\sigma_3=80^\circ 58'\cdot6$	$S_4=0\cdot0272$ $\sigma_4=225^\circ 20'\cdot3$	$S_5=0\cdot0152$ $\sigma_5=264^\circ 12'\cdot8$	$S_6=0\cdot0282$ $\sigma_6=180^\circ 0'\cdot0$

TABLE IX.—Secondary Constants for S.

$\overset{1}{K}_{0}=3\cdot8177$	$\overset{1}{K}_{1}=2\cdot5130$ $\overset{1}{\varkappa}_{1}=93^\circ\,52'\cdot1$	$\overset{1}{K}_{2}=0\cdot8748$ $\overset{1}{\varkappa}_{2}=63^\circ\,28'\cdot5$	$\overset{1}{K}_{3}=0\cdot9444$ $\overset{1}{\varkappa}_{3}=66^\circ\,16'\cdot5$	$\overset{1}{K}_{4}=0\cdot2678$ $\overset{1}{\varkappa}_{4}=150^\circ\,17'\cdot6$	$\overset{1}{K}_{5}=0\cdot5199$ $\overset{1}{\varkappa}_{5}=182^\circ\,59'\cdot8$	$\overset{1}{K}_{6}=0\cdot3894$ $\overset{1}{\varkappa}_{6}=180^\circ\,0'\cdot0$
$\overset{1}{A}_{0}=-0\cdot0749$	$\overset{1}{A}_{1}=0\cdot1361$ $\overset{1}{\alpha}_{1}=127^\circ\,43'\cdot2$	$\overset{1}{A}_{2}=0\cdot1062$ $\overset{1}{\alpha}_{2}=227^\circ\,53'\cdot9$	$\overset{1}{A}_{3}=0\cdot0628$ $\overset{1}{\alpha}_{3}=195^\circ\,36'\cdot3$	$\overset{1}{A}_{4}=0\cdot1319$ $\overset{1}{\alpha}_{4}=80^\circ\,54'\cdot3$	$\overset{1}{A}_{5}=0\cdot1183$ $\overset{1}{\alpha}_{5}=118^\circ\,31'\cdot6$	$\overset{1}{A}_{6}=0\cdot0600$ $\overset{1}{\alpha}_{6}=180^\circ\,0'\cdot0$
$\overset{1}{B}_{0}=0\cdot1932$	$\overset{1}{B}_{1}=0\cdot0658$ $\overset{1}{\beta}_{1}=5^\circ\,8'\cdot8$	$\overset{1}{B}_{2}=0\cdot1265$ $\overset{1}{\beta}_{2}=330^\circ\,3'\cdot5$	$\overset{1}{B}_{3}=0\cdot0272$ $\overset{1}{\beta}_{3}=18^\circ\,14'\cdot3$	$\overset{1}{B}_{4}=0\cdot0405$ $\overset{1}{\beta}_{4}=211^\circ\,32'\cdot3$	$\overset{1}{B}_{5}=0\cdot0432$ $\overset{1}{\beta}_{5}=248^\circ\,27'\cdot0$	$\overset{1}{B}_{6}=0\cdot0247$ $\overset{1}{\beta}_{6}=180^\circ\,0'\cdot0$
$\overset{1}{C}_{0}=-0\cdot0597$	$\overset{1}{C}_{1}=0\cdot1294$ $\overset{1}{\gamma}_{1}=290^\circ\,14'\cdot5$	$\overset{1}{C}_{2}=0\cdot0590$ $\overset{1}{\gamma}_{2}=206^\circ\,16'\cdot4$	$\overset{1}{C}_{3}=0\cdot0153$ $\overset{1}{\gamma}_{3}=163^\circ\,19'\cdot2$	$\overset{1}{C}_{4}=0\cdot0737$ $\overset{1}{\gamma}_{4}=252^\circ\,17'\cdot4$	$\overset{1}{C}_{5}=0\cdot0642$ $\overset{1}{\gamma}_{5}=273^\circ\,32'\cdot0$	$\overset{1}{C}_{6}=0\cdot0270$ $\overset{1}{\gamma}_{6}=180^\circ\,0'\cdot0$
$\overset{1}{D}_{0}=-0\cdot0083$	$\overset{1}{D}_{1}=0\cdot0284$ $\overset{1}{\delta}_{1}=199^\circ\,28'\cdot2$	$\overset{1}{D}_{2}=0\cdot0455$ $\overset{1}{\delta}_{2}=49^\circ\,15'\cdot3$	$\overset{1}{D}_{3}=0\cdot0390$ $\overset{1}{\delta}_{3}=220^\circ\,55'\cdot3$	$\overset{1}{D}_{4}=0\cdot0198$ $\overset{1}{\delta}_{4}=257^\circ\,13'\cdot3$	$\overset{1}{D}_{5}=0\cdot0429$ $\overset{1}{\delta}_{5}=83^\circ\,59'\cdot9$	$\overset{1}{D}_{6}=0\cdot0179$ $\overset{1}{\delta}_{6}=180^\circ\,0'\cdot0$
$\overset{1}{O}_{0}=0\cdot2715$	$\overset{1}{O}_{1}=0\cdot2265$ $\overset{1}{o}_{1}=324^\circ\,48'\cdot8$	$\overset{1}{O}_{2}=0\cdot1762$ $\overset{1}{o}_{2}=278^\circ\,25'\cdot5$	$\overset{1}{O}_{3}=0\cdot2199$ $\overset{1}{o}_{3}=211^\circ\,4'\cdot6$	$\overset{1}{O}_{4}=0\cdot1341$ $\overset{1}{o}_{4}=141^\circ\,41'\cdot0$	$\overset{1}{O}_{5}=0\cdot1469$ $\overset{1}{o}_{5}=72^\circ\,50'\cdot9$	$\overset{1}{O}_{6}=0\cdot0400$ $\overset{1}{o}_{6}=180^\circ\,0'\cdot0$
$\overset{1}{P}_{0}-0\cdot0226$	$\overset{1}{P}_{1}=0\cdot1098$ $\varpi_{1}=292^\circ\,1'\cdot8$	$\overset{1}{P}_{2}=0\cdot0936$ $\varpi_{2}=101^\circ\,28'\cdot8$	$\overset{1}{P}_{3}=0\cdot0097$ $\varpi_{3}=182^\circ\,35'\cdot5$	$\overset{1}{P}_{4}=0\cdot0992$ $\varpi_{4}=5^\circ\,40'\cdot3$	$\overset{1}{P}_{5}=0\cdot0699$ $\varpi_{5}=43^\circ\,57'\cdot6$	$\overset{1}{P}_{6}=0\cdot0327$ $\varpi_{6}=180^\circ\,0'\cdot0$
$\overset{1}{R}_{0}=-0\cdot0315$	$\overset{1}{R}_{1}=0\cdot0285$ $\overset{1}{\rho}_{1}=342^\circ\,57'\cdot0$	$\overset{1}{R}_{2}=0\cdot0216$ $\overset{1}{\rho}_{2}=40^\circ\,45'\cdot9$	$\overset{1}{R}_{3}=0\cdot0407$ $\overset{1}{\rho}_{3}=39^\circ\,8'\cdot0$	$\overset{1}{R}_{4}=0\cdot0269$ $\overset{1}{\rho}_{4}=61^\circ\,35'\cdot7$	$\overset{1}{R}_{5}=0\cdot0453$ $\overset{1}{\rho}_{5}=30^\circ\,13'\cdot3$	$\overset{1}{R}_{6}=0\cdot0343$ $\overset{1}{\rho}_{6}=0^\circ\,0'\cdot0$
$S_{0}=-0\cdot0487$	$\overset{1}{S}_{1}=0\cdot0508$ $\overset{1}{\sigma}_{1}=44^\circ\,29'\cdot7$	$\overset{1}{S}_{2}=0\cdot0023$ $\overset{1}{\sigma}_{2}=280^\circ\,53'\cdot1$	$\overset{1}{S}_{3}=0\cdot0452$ $\overset{1}{\sigma}_{3}=186^\circ\,38'\cdot1$	$\overset{1}{S}_{4}=0\cdot0283$ $\overset{1}{\sigma}_{4}=95^\circ\,19'\cdot5$	$\overset{1}{S}_{5}=0\cdot0565$ $\overset{1}{\sigma}_{5}=304^\circ\,41'\cdot1$	$\overset{1}{S}_{6}=0\cdot0526$ $\overset{1}{\sigma}_{6}=0^\circ\,0'\cdot0$

work in computing, has this advantage, that it permits the combining the constants obtained at different periods by simple meaning, which the sine formula does not. It also lends itself more easily to an examination of any influence which may be supposed to change the coordinates periodically. Any such may be developed in a similar series, and the sum or difference of the two will give the residual part which is to be accounted for by other causes. If this residue be larger than the original periodic part, the hypothesis must be rejected; and even though it be diminished, this is not sufficient unless there be *à priori* evidence of a *vera causa.* As an example of this may be mentioned one of the elements of the sun's action. Its heating-power on a given day depends, among other things, on the sum of the sines of its altitude during that day. This sum

$$=2\int_{\theta'}^{180-\theta'} d\theta\{\sin \text{lat.} \sin \text{declin.} - \cos \text{lat.} \cos \text{decl.} \sin \theta\}$$

$$=2 \sin \text{lat.} \sin \text{decl.} \times \theta' + 2 \cos \text{lat.} \cos \text{decl.} \sin \theta',$$

θ' being the value of θ at sunrise. If the value of this integral be computed for 12 values of φ, it can be developed in a series $y=k+a \cos \varphi + o \sin \varphi + b \cos 2\varphi +$ &c. This belongs to the midday of each month, and ought in strictness to be summed for the entire month by means of the expression of decl. in terms of φ; but it is sufficient for illustration. u is evidently diminished by y, and we have what would be found if the altitude had no effect,

$$x=u+qy=\text{K}+kq+\cos \varphi(\text{A}+aq)+\sin \varphi(\text{O}+oq)+\cos 2\varphi(\text{B}+bq)+\&\text{c.}$$

If q, the measure of the altitude's effect on the coordinates, were known, no more would be required; but a probable value of it is that which would make the sum of the squares of the periodic parts of the residues or $\text{S}(u_\varphi+qy_\varphi-\text{K}-k)$ a minimum. This gives $q(\text{S}y^2-12k^2)=-\text{S}uy+12\text{K}k$.

For K$q=2·422$; for K$'u=4·723$. With these I computed the series for x and x', which need not be given, remarking merely that the coefficients of the first order are the only ones much altered. It may suffice to give the variable parts of u, x; u', x'.

January.	February.	March.	April.	May.	June.	July.	Aug.	Sept.	October.	Nov.	Dec.
2·109	0·778	2·758	−1·931	−1·715	−1·576	0·438	0·217	−0·180	−0·361	−0·386	1·658
1·016	0·032	2·630	−1·258	−0·575	−0·299	0·680	0·886	−0·150	−0·929	−1·397	0·467
3·170	2·190	−0·541	−1·345	−1·596	−2·068	−2·278	−1·196	−0·102	0·017	0·173	3·879
1·030	0·778	−1·092	−0·137	0·398	0·420	−0·100	0·117	−0·045	−1·092	−1·800	1·655

It seems from these numbers that the sun's altitude may account for 0·27 of the variation of W, and for 0·53 of that of S.

This discussion suggests the notion that the equatorial current which produces the positive W and S coordinates may possibly be more constant than appears at first sight, and that a part of these variations may be due to a current in the opposite direction caused by the solar action in the vicinity of the place of observation and varying with the sun's declination. Supposing $q\underset{\varphi}{y}$ to be that part of it due to the altitude, its mean annual value would be $V=2{\cdot}721$, about 0·6 of V' (page 412), and its $D=207^\circ\ 8'{\cdot}7$. Other periodical causes, such as the length of air traversed by the sun's rays at different altitudes, the difference of the earth's daily and nightly radiations, and the amount of watery vapour in the air, might be similarly taken into account.

I have already stated that I thought it useless to deal with the observations of single days; I, however, tried two experiments in this direction, which may be of some interest, though the first of them was unsuccessful.

1. In many instances, even when the wind is moderate, there are variations in its direction which suggest the notion that they are due to aerial whirlpools on so small a scale that they are not likely to reach any other meteorological station.

I thought it might be possible to determine the constants of such a motion in the following way. The curve described on such a supposition by the thread of wind which passes the anemometer at a given station is that which would be traced by a pencil fixed there on a plane revolving with an angular hourly velocity ω' round a centre which is carried in a line inclined at the angle α to the axis of x with the hourly velocity V, ξ and η being the coordinates of that centre at the origin of the time, and ω the angular motion there. It is obvious that we have

$$dx=dt\{V\cos\alpha(1+\omega' t)+\xi\omega'\},\ dy=dt\{V\sin\alpha(1+\omega' t)-\eta\omega'\}.$$

Then at successive hours equating $\frac{dy}{dx}$ to tang D, and $\int\sqrt{dx^2+dy^2}$ to s, I would be able to get values of the unknown quantities. But against this is my ignorance of the relation between ω' and this distance from the centre of the circle, which is not given in any book to which I can refer. NEWTON, in the vortex which he considers, gives it inversely as the distance. It is probably nearer the inverse square. Either of these suppositions would make direct integration impossible, so I gave up the project.

2. The other was an attempt to determine from these observations the existence of an atmospheric tidal current. As in the case of the ocean, so in the atmosphere, the air must be heaped up in the meridian passing through the moon, or a little to the east of it; and this elevation must be accompanied by a horizontal current.

LAPLACE (Méc. Cél. ii.) has shown that the maximum air-tidal current is 0·07532 metre in a centesimal second*, which in English measure and time is 0·195 mile in an hour. He, however, gives no indication of the phase of this maximum, or in what stratum of the atmosphere it occurs. At the earth's surface, owing to friction and other causes, it must be considerably less than the above value, and the analogy of sea-tides is too slight to give much assistance in the research. It may, however, authorize us to assume that on opposite sides of the lunar meridian the directions of this current will be opposite.

---

* It is to be regretted that in this noble work LAPLACE used the centesimal division of the quadrant, and the decimal and centesimal divisions of the day. Whatever be the fate of the metric system, it is very unlikely that either of the others will be generally adopted.

Having no data to guide me in detecting the most favourable Lunar hours, I began by comparing the Ws for 0^h, 6^h, 12^h, 18^h, and 3^h, 9^h, 15^h, 21^h. I soon, however, found that this involved too much labour, and confined myself to the last hour.

Calling C′ the current, $C'=\frac{1}{2}\left(\underset{21}{W}-\underset{3}{W'}\right),=\frac{1}{2}\left(\underset{9}{W}-\underset{15}{W'}\right)$. In this I made no attempt to allow for the sun's elongation from the moon, or for their declination, nor for the horary changes of the coordinates, as the selected lunars are nearly uniformly distributed in each of the 24 common hours.

By a Table with the moon's hourly motion in Right Ascension for argument I found the time which should be added to the Greenwich time of its culmination to obtain the common time of the above-named lunar hours at Armagh, and entering the Journal with these I obtained for each day two values of $\frac{1}{2}(W-W')$, belonging to the upper and lower culminations. From the irregularity of these values it might seem hopeless to get any result; but I pursued the inquiry in hopes of ascertaining the limits within which the mean of a considerable number of observations (even though very discordant) might be depended on.

I only took the first six months of the year, as the results which they gave were quite satisfactory.

Table X.

Month.	Current.	No.	P E	Weight.	C×W.	
January	0·2289	404	±1·939	1·000	0·2289	The mean according to the weight.
February	0·1549	376	±1·809	1·020	0·1580	
March..............	−0·0414	415	±1·886	1·082	−0·0459	
April	0·0072	396	±1·737	1·190	0·0084	C′=0·0906. Not differing much from the single mean.
May	0·0844	423	±1·345	2·175	0·1837	
June	0·1125	404	±1·247	2·416	0·2720	
	0·0911	2418	±1·661	8·883	0·8051	

The weights are proportional, the least, that for January, being taken as unity. It will be observed that these probable errors are far less than those given in page 415; but it should be recollected that here the variations can only occur within 6 lunar hours, while in the other case they range through months and years. Even so there are occasionally very great and startling changes when a gale bursts out suddenly or suddenly ceases. There were two values of W−W′ above 40, and three above 30. Yet with all this I think the result is very remarkable. I do not pretend to assert that this value of C′ really represents the tidal current at these hours, though it is in the right direction and of not improbable amount; for it may be some uncompensated residue of the horary changes. But it is of great importance, as giving what must be a close approximation to the real value of the average air-tidal stream, and as verifying my former statements, that casual irregularities are eliminated from the mean of a large number of observations. Still I think that a truer result might be obtained by omitting extremely aberrant observations; but it becomes a question to what extent this should be done. I think all may be rejected which exceed four times the largest probable error; in other words, whose probability is less than 0·0228. This is for $W-W'$ all above 15. The number of these is 58, and the results after their exclusion are given in Table XI.

TABLE XI.

Month.	Current.	No.	P E	Weight.	C×W.	
January	0·1498	386	±1·592	1·321	0·1979	The mean according to the weights is $C''=0·0559$.
February	0·2483	366	±1·607	1·317	0·3204	
March..............	−0·0423	406	±1·726	1·266	−0·0535	
April	−0·0590	381	±1·657	1·289	−0·0760	
May	0·0010	419	±1·262	2·438	0·0024	
June	0·0718	402	±1·204	2·496	0·1753	
	0·0608	2360	±1·443	10·127	0·5665	

The probable errors are less, and the weights greater than in the other case, so that C'' is probably a better value than C'.

It is possible that this mode of proceeding might give the horary changes of the coordinates more correctly than the simple comparison of the numbers in Table III.; but the labour of computation would be much greater.